

EXHIBIT 14



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(54) **COMMUNICATIONS EQUIPMENT
HOUSINGS, ASSEMBLIES, AND RELATED
ALIGNMENT FEATURES AND METHODS**

(56) **References Cited**

U.S. PATENT DOCUMENTS

(75) Inventors: **Chois A. Blackwell, Jr.**, North Richland Hills, TX (US); **Terry D. Cox**, Keller, TX (US)

620,013	A	2/1899	Barnes
2,614,685	A	10/1952	Miller
3,175,873	A	3/1965	Blomquist et al.
3,212,192	A	10/1965	Bachmann et al.
3,568,263	A	3/1971	Meehan
3,880,396	A	4/1975	Freiberger et al.

(73) Assignee: **Corning Cable Systems LLC**, Hickory, NC (US)

(Continued)

FOREIGN PATENT DOCUMENTS

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CA	2029592	A1	5/1992
CA	2186314	A1	4/1997

(Continued)

OTHER PUBLICATIONS

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(57) **ABSTRACT**

Communications system housings, assemblies, and related alignment features and methods are disclosed. In certain embodiments, communications cards and related assemblies and methods that include one or more alignment features are disclosed. In certain embodiments, at least one digital connector disposed in the communications card is configured to engage at least one complementary digital connector to align at least one RF connector also disposed in the communications card with at least one complementary RF connector. In other embodiments, printed circuit board (PCB) assemblies are disclosed that include a moveable standoff to provide an alignment feature. In other embodiments, distributed antenna systems and assemblies that include one or more alignment features are disclosed. In certain embodiments, an enclosure is provided that includes a midplane support configured to support a midplane interface card in a datum plane for establishing at least one connection to at least one distributed antenna system component.

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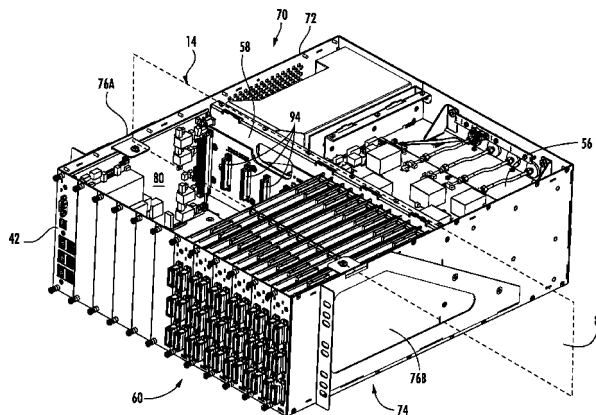
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See application file for complete search history.

30 Claims, 42 Drawing Sheets



US 8,593,828 B2

Page 2

(56)

References Cited

U.S. PATENT DOCUMENTS

3,906,592	A	9/1975	Sakasegawa et al.	5,231,688	A	7/1993	Zimmer
4,047,797	A	9/1977	Arnold et al.	5,233,674	A	8/1993	Vladic
4,059,872	A	11/1977	Delesandri	5,239,609	A	8/1993	Auteri
4,119,285	A	10/1978	Bisping et al.	5,243,679	A	9/1993	Sharrow et al.
4,239,316	A	12/1980	Spaulding	5,253,320	A	10/1993	Takahashi et al.
4,285,486	A	8/1981	Von Osten et al.	5,260,957	A	11/1993	Hakimi et al.
4,354,731	A	10/1982	Mouissie	5,261,633	A	11/1993	Mastro
4,457,482	A	7/1984	Kitagawa	5,265,187	A	11/1993	Morin et al.
4,525,012	A	6/1985	Dunner	5,274,731	A	12/1993	White
4,597,173	A	7/1986	Chino et al.	5,280,138	A	1/1994	Preston et al.
4,611,875	A	9/1986	Clarke et al.	5,285,515	A	2/1994	Milanowski et al.
4,645,292	A	2/1987	Sammueler	5,315,679	A	5/1994	Baldwin et al.
4,657,340	A	4/1987	Tanaka et al.	5,317,663	A	5/1994	Beard et al.
4,702,551	A	10/1987	Coulombe	5,323,478	A	6/1994	Milanowski et al.
4,736,100	A	4/1988	Vastagh	5,323,480	A	6/1994	Mullaney et al.
4,744,629	A	5/1988	Bertoglio et al.	5,333,193	A	7/1994	Cote et al.
4,747,020	A	5/1988	Brickley et al.	5,333,221	A	7/1994	Briggs et al.
4,752,110	A	6/1988	Blanchet et al.	5,333,222	A	7/1994	Belenkiy et al.
4,787,706	A	11/1988	Cannon, Jr. et al.	5,337,400	A	8/1994	Morin et al.
4,792,203	A	12/1988	Nelson et al.	5,339,379	A	8/1994	Kutsch et al.
4,798,432	A	1/1989	Becker et al.	5,347,603	A	9/1994	Belenkiy et al.
4,808,774	A	2/1989	Crane	5,353,367	A	10/1994	Czosnowski et al.
4,824,193	A	4/1989	Maeda et al.	5,359,688	A	10/1994	Underwood
4,824,196	A	4/1989	Bylander	5,363,466	A	11/1994	Milanowski et al.
4,826,277	A	5/1989	Weber et al.	5,366,388	A	11/1994	Freeman et al.
4,838,643	A	6/1989	Hodges et al.	5,367,598	A	11/1994	Devenish, III et al.
4,865,280	A	9/1989	Wollar	5,373,421	A	12/1994	Detsikas et al.
4,898,448	A	2/1990	Cooper	5,383,051	A	1/1995	Delrosso et al.
4,900,123	A	2/1990	Barlow	5,390,272	A	2/1995	Repta et al.
4,911,662	A	3/1990	Debortoli et al.	5,398,295	A	3/1995	Chang et al.
4,948,220	A	8/1990	Violo et al.	5,398,820	A	3/1995	Kiss
4,949,376	A	8/1990	Nieves et al.	5,399,814	A	3/1995	Staber et al.
4,971,421	A	11/1990	Ori	5,401,193	A	3/1995	Lo Cicero et al.
4,991,928	A	2/1991	Zimmer	5,402,515	A	3/1995	Vidacovich et al.
4,995,688	A	2/1991	Anton et al.	5,408,557	A	4/1995	Hsu
5,001,602	A	3/1991	Suffi et al.	RE34,955	E	5/1995	Anton et al.
5,005,941	A	4/1991	Barlow et al.	5,412,751	A	5/1995	Siemon et al.
5,017,211	A	5/1991	Wenger et al.	5,416,837	A	5/1995	Cote et al.
5,023,646	A	6/1991	Ishida et al.	5,418,874	A	5/1995	Carlisle et al.
5,024,498	A	6/1991	Becker et al.	5,420,956	A	5/1995	Grugel et al.
5,028,114	A	7/1991	Krausse et al.	5,420,958	A	5/1995	Henson et al.
5,037,175	A	8/1991	Weber	5,438,641	A	8/1995	Malacarne
5,048,918	A	9/1991	Daems et al.	5,442,725	A	8/1995	Peng
5,066,149	A	11/1991	Wheeler et al.	5,442,726	A	8/1995	Howard et al.
5,067,784	A	11/1991	Debortoli et al.	5,443,232	A	8/1995	Kesinger et al.
5,071,211	A	12/1991	Debortoli et al.	5,444,804	A	8/1995	Yui et al.
5,071,220	A	12/1991	Ruello et al.	5,448,015	A	9/1995	Jamet et al.
5,073,042	A	12/1991	Mulholland et al.	5,450,518	A	9/1995	Burek et al.
5,074,635	A	12/1991	Justice et al.	5,458,019	A	10/1995	Trevino
5,076,688	A	12/1991	Bowen et al.	5,471,555	A	11/1995	Braga et al.
5,080,459	A	1/1992	Wettengel et al.	5,479,505	A	12/1995	Butler et al.
5,100,221	A	3/1992	Carney et al.	5,481,634	A	1/1996	Anderson et al.
5,104,336	A	4/1992	Hatanaka et al.	5,481,939	A	1/1996	Bernardini
5,125,060	A	6/1992	Edmundson	5,490,229	A	2/1996	Ghandeharizadeh et al.
5,127,082	A	6/1992	Below et al.	5,497,416	A	3/1996	Butler, III et al.
5,127,851	A	7/1992	Hilbert et al.	5,497,444	A	3/1996	Wheeler
5,129,030	A	7/1992	Petrunia	5,511,144	A	4/1996	Hawkins et al.
5,133,039	A	7/1992	Dixit	5,511,798	A	4/1996	Kawamoto et al.
5,138,678	A	8/1992	Briggs et al.	5,519,804	A	5/1996	Burek et al.
5,138,688	A	8/1992	Debortoli	5,542,015	A	7/1996	Hultermans
5,142,598	A	8/1992	Tabone	5,546,495	A	8/1996	Bruckner et al.
5,142,607	A	8/1992	Petrotta et al.	5,548,641	A	8/1996	Butler et al.
5,150,277	A	9/1992	Bainbridge et al.	5,553,183	A	9/1996	Bechamps
D330,368	S	10/1992	Bourgeois et al.	5,553,186	A	9/1996	Allen
5,152,760	A	10/1992	Latina	5,572,617	A	11/1996	Bernhardt et al.
5,153,910	A	10/1992	Mickelson et al.	5,575,680	A	11/1996	Suffi
5,157,749	A	10/1992	Briggs et al.	5,577,151	A	11/1996	Hoffer
5,167,001	A	11/1992	Debortoli et al.	5,590,234	A	12/1996	Pulido
5,170,452	A	12/1992	Ott	5,595,507	A	1/1997	Braun et al.
5,189,723	A	2/1993	Johnson et al.	5,600,020	A	2/1997	Wehle et al.
5,204,929	A	4/1993	Machall et al.	5,602,954	A	2/1997	Nolf et al.
5,209,572	A	5/1993	Jordan	5,608,606	A	3/1997	Blanney 361/679.32
5,214,735	A	5/1993	Henneberger et al.	5,613,030	A	3/1997	Hoffer et al.
5,224,186	A	6/1993	Kishimoto et al.	5,617,501	A	4/1997	Miller et al.
5,231,687	A	7/1993	Handley	5,638,474	A	6/1997	Lampert et al.
				5,640,476	A	6/1997	Womack et al.
				5,640,482	A	6/1997	Barry et al.
				5,647,043	A	7/1997	Anderson et al.
				5,647,045	A	7/1997	Robinson et al.

US 8,593,828 B2

Page 3

5,650,334 A	7/1997	Zuk et al.	6,058,235 A	5/2000	Hiramatsu et al.
5,668,911 A	9/1997	Debortoli	6,061,492 A	5/2000	Strause et al.
5,671,273 A	9/1997	Lanquist	6,078,661 A	6/2000	Arnett et al.
5,689,605 A	11/1997	Cobb et al.	6,079,881 A	6/2000	Roth
5,689,607 A	11/1997	Vincent et al.	6,127,627 A	10/2000	Daoud
5,694,511 A	12/1997	Pimpinella et al.	6,130,983 A	10/2000	Cheng
5,701,380 A	12/1997	Larson et al.	6,134,370 A	10/2000	Childers et al.
5,708,742 A	1/1998	Beun et al.	6,149,313 A	11/2000	Giebel et al.
5,708,751 A	1/1998	Mattei	6,149,315 A	11/2000	Stephenson
5,710,851 A	1/1998	Walter et al.	6,151,432 A	11/2000	Nakajima et al.
5,717,810 A	2/1998	Wheeler	6,160,946 A	12/2000	Thompson et al.
5,734,776 A	3/1998	Puetz	6,181,861 B1	1/2001	Wenski et al.
5,740,300 A	4/1998	Hodge	6,188,687 B1	2/2001	Mussman et al.
5,742,982 A	4/1998	Dodd et al.	6,188,825 B1	2/2001	Bandy et al.
5,751,874 A	5/1998	Chudoba et al.	6,192,180 B1	2/2001	Kim et al.
5,751,882 A	5/1998	Daems et al.	6,201,920 B1	3/2001	Noble et al.
5,758,003 A	5/1998	Wheeler et al.	6,208,796 B1	3/2001	Williams Vigliaturo
5,758,004 A	5/1998	Alarcon et al.	6,212,324 B1	4/2001	Lin et al.
5,761,026 A	6/1998	Robinson et al.	6,215,938 B1	4/2001	Reitmeier et al.
5,769,908 A	6/1998	Koppelman	6,227,717 B1	5/2001	Ott et al.
5,774,612 A	6/1998	Belenkiy et al.	6,234,683 B1	5/2001	Waldron et al.
5,778,122 A	7/1998	Giebel et al.	6,234,685 B1	5/2001	Carlisle et al.
5,778,130 A	7/1998	Walters et al.	6,236,795 B1	5/2001	Rodgers
5,781,686 A	7/1998	Robinson et al.	6,240,229 B1	5/2001	Roth
5,790,741 A	8/1998	Vincent et al.	6,243,522 B1	6/2001	Allan et al.
5,793,920 A	8/1998	Wilkins et al.	6,245,998 B1	6/2001	Curry et al.
5,793,921 A	8/1998	Wilkins et al.	6,263,141 B1	7/2001	Smith
5,796,908 A	8/1998	Vicory	6,265,680 B1	7/2001	Robertson
5,813,867 A	9/1998	Hodge	6,269,212 B1	7/2001	Schiattone
5,823,646 A	10/1998	Arizpe et al.	6,275,641 B1	8/2001	Daoud
5,825,955 A	10/1998	Ernst et al.	6,278,829 B1	8/2001	BuAbbud et al.
5,825,961 A	10/1998	Wilkins et al.	6,278,831 B1	8/2001	Henderson et al.
5,828,807 A	10/1998	Tucker et al.	D448,005 S	9/2001	Klein, Jr. et al.
5,832,162 A	11/1998	Sarbell	6,292,614 B1	9/2001	Smith et al.
5,835,657 A	11/1998	Suarez et al.	6,301,424 B1	10/2001	Hwang
5,835,658 A	11/1998	Smith	6,307,997 B1	10/2001	Walters et al.
5,862,290 A	1/1999	Burek et al.	6,318,824 B1	11/2001	LaGrotta et al.
5,870,519 A	2/1999	Jenkins et al.	6,321,017 B1	11/2001	Janus et al.
5,874,733 A	2/1999	Silver et al.	6,322,279 B1	11/2001	Yamamoto et al.
5,877,565 A	3/1999	Hollenbach et al.	6,325,549 B1	12/2001	Shevchuk
5,880,864 A	3/1999	Williams et al.	RE37,489 E	1/2002	Anton et al.
5,881,200 A	3/1999	Burt	6,343,313 B1	1/2002	Salesky et al.
5,883,995 A	3/1999	Lu	6,347,888 B1	2/2002	Puetz
5,884,003 A	3/1999	Cloud et al.	6,353,696 B1	3/2002	Gordon et al.
5,887,095 A	3/1999	Nagase et al.	6,353,697 B1	3/2002	Daoud
5,887,106 A	3/1999	Cheeseman et al.	6,359,228 B1	3/2002	Strause et al.
5,892,877 A	4/1999	Meyerhoefer	6,363,200 B1	3/2002	Thompson et al.
5,894,540 A	4/1999	Drewing	6,370,309 B1	4/2002	Daoud
5,901,220 A	5/1999	Garver et al.	6,377,218 B1*	4/2002	Nelson et al.
5,903,693 A	5/1999	Brown	6,379,052 B1	4/2002	De Jong et al.
5,909,298 A	6/1999	Shimada et al.	6,385,381 B1	5/2002	Janus et al.
5,913,006 A	6/1999	Summach	6,389,214 B1	5/2002	Smith et al.
5,914,976 A	6/1999	Jayaraman et al.	6,397,166 B1	5/2002	Leung et al.
5,915,055 A	6/1999	Bennett et al.	6,398,149 B1	6/2002	Hines et al.
5,923,804 A	7/1999	Rosson	6,411,767 B1	6/2002	Burrous et al.
5,930,425 A	7/1999	Abel et al.	6,418,262 B1	7/2002	Puetz et al.
5,933,557 A	8/1999	Ott	6,424,781 B1	7/2002	Puetz et al.
5,943,460 A	8/1999	Mead et al.	6,425,694 B1	7/2002	Szilagyi et al.
5,945,633 A	8/1999	Ott et al.	6,427,045 B1	7/2002	Matthes et al.
5,946,440 A	8/1999	Puetz	6,431,762 B1	8/2002	Taira et al.
5,949,946 A	9/1999	Debortoli et al.	6,434,313 B1	8/2002	Clapp, Jr. et al.
5,953,962 A	9/1999	Hewson	6,438,310 B1	8/2002	Lance et al.
5,956,439 A	9/1999	Pimpinella	6,452,925 B1	9/2002	Sistanizadeh et al.
5,956,444 A	9/1999	Duda et al.	6,456,773 B1	9/2002	Keys
5,966,492 A	10/1999	Bechamps et al.	6,464,402 B1	10/2002	Andrews et al.
5,969,294 A	10/1999	Eberle et al.	6,466,724 B1	10/2002	Glover et al.
5,975,769 A	11/1999	Larson et al.	6,469,905 B1	10/2002	Hwang
5,978,540 A	11/1999	Bechamps et al.	D466,087 S	11/2002	Cuny et al.
5,980,303 A	11/1999	Lee et al.	6,478,472 B1	11/2002	Anderson et al.
5,993,071 A	11/1999	Hultermans	6,480,487 B1	11/2002	Wegleitner et al.
5,995,700 A	11/1999	Burek et al.	6,480,660 B1	11/2002	Reitmeier et al.
5,999,393 A	12/1999	Brower	6,483,977 B2	11/2002	Batthey et al.
6,001,831 A	12/1999	Papenfuhs et al.	6,484,958 B1	11/2002	Xue et al.
6,009,224 A	12/1999	Allen	6,496,640 B1	12/2002	Harvey et al.
6,009,225 A	12/1999	Ray et al.	6,504,988 B1	1/2003	Trebesch et al.
6,011,831 A	1/2000	Nieves et al.	6,507,980 B2	1/2003	Bremicker
6,027,252 A	2/2000	Erdman et al.	6,510,274 B1	1/2003	Wu et al.
6,044,193 A	3/2000	Szentesi et al.	6,532,332 B2	3/2003	Solheid et al.
			6,533,472 B1	3/2003	Dinh et al.

US 8,593,828 B2

Page 4

6,535,397 B2 *	3/2003	Clark et al.	361/788	6,870,997 B2	3/2005	Cooke
6,539,147 B1	3/2003	Mahony		6,879,545 B2	4/2005	Cooke et al.
6,539,160 B2	3/2003	Batthey et al.		6,915,058 B2	7/2005	Pons
6,542,688 B1	4/2003	Batthey et al.		6,920,273 B2	7/2005	Knudsen
6,550,977 B2	4/2003	Hizuka		6,920,274 B2	7/2005	Rapp et al.
6,554,485 B1	4/2003	Beatty et al.		6,925,241 B2	8/2005	Bohle et al.
6,560,334 B1	5/2003	Mullaney et al.		6,934,451 B2	8/2005	Cooke
6,567,601 B2	5/2003	Daoud et al.		6,934,456 B2	8/2005	Ferris et al.
6,571,048 B1	5/2003	Bechamps et al.		6,937,807 B2	8/2005	Franklin et al.
6,577,595 B1	6/2003	Counterman		6,944,383 B1	9/2005	Herzog et al.
6,577,801 B2	6/2003	Broderick et al.		6,944,389 B2	9/2005	Giraud et al.
6,579,014 B2	6/2003	Melton et al.		6,963,690 B1	11/2005	Kassal et al.
6,584,267 B1	6/2003	Caveney et al.		6,968,107 B2	11/2005	Belardi et al.
6,587,630 B2	7/2003	Spence et al.		6,968,111 B2	11/2005	Trebesch et al.
6,588,938 B1	7/2003	Lampert et al.		6,985,665 B2	1/2006	Baechtle
6,591,051 B2	7/2003	Solheid et al.		6,993,237 B2	1/2006	Cooke et al.
6,592,266 B1	7/2003	Hankins et al.		7,000,784 B2	2/2006	Canty et al.
6,597,670 B1	7/2003	Tweedy et al.		7,005,582 B2	2/2006	Muller et al.
6,600,866 B2	7/2003	Gatica et al.		7,006,748 B2	2/2006	Dagley et al.
6,601,997 B2	8/2003	Ngo		7,007,296 B2	2/2006	Rakib
6,612,515 B1	9/2003	Tinucci et al.		7,027,695 B2	4/2006	Cooke et al.
6,614,978 B1	9/2003	Caveney		7,027,706 B2	4/2006	Diaz et al.
6,614,980 B1	9/2003	Mahony		7,031,588 B2	4/2006	Cowley et al.
6,621,975 B2	9/2003	Laporte et al.		7,035,510 B2	4/2006	Zimmel et al.
6,625,374 B2	9/2003	Holman et al.		7,038,137 B2	5/2006	Grubish et al.
6,625,375 B1	9/2003	Mahony		7,054,513 B2	5/2006	Herz et al.
6,631,237 B2	10/2003	Knudsen et al.		7,066,748 B2	6/2006	Bricaud et al.
6,640,042 B2	10/2003	Araki et al.		7,068,907 B2	6/2006	Schray
RE38,311 E	11/2003	Wheeler		7,070,459 B2	7/2006	Denovich et al.
6,644,863 B1	11/2003	Azami et al.		7,079,744 B2	7/2006	Douglas et al.
6,647,197 B1	11/2003	Marrs et al.		7,090,406 B2	8/2006	Melton et al.
6,648,520 B2	11/2003	McDonald et al.		7,090,407 B2	8/2006	Melton et al.
6,654,536 B2	11/2003	Batthey et al.		7,094,095 B1	8/2006	Caveney
6,668,127 B1	12/2003	Mahony		7,097,047 B2	8/2006	Lee et al.
6,677,520 B1	1/2004	Kim et al.		7,101,093 B2	9/2006	Hsiao et al.
6,679,604 B1	1/2004	Bove et al.		7,102,884 B2	9/2006	Mertesdorf et al.
6,687,450 B1	2/2004	Kempeneers et al.		7,103,255 B2	9/2006	Reagan et al.
6,710,366 B1	3/2004	Lee et al.		7,110,654 B2	9/2006	Dillat
6,715,619 B2	4/2004	Kim et al.		7,111,990 B2	9/2006	Melton et al.
6,719,149 B2	4/2004	Tomino		7,113,679 B2	9/2006	Melton et al.
6,741,784 B1	5/2004	Guan		7,113,686 B2	9/2006	Bellekens et al.
6,741,785 B2	5/2004	Barthel et al.		7,113,687 B2	9/2006	Womack et al.
6,746,037 B1	6/2004	Kaplenski et al.		7,116,491 B1	10/2006	Willey et al.
6,748,154 B2	6/2004	O'Leary et al.		7,116,883 B2	10/2006	Kline et al.
6,748,155 B2	6/2004	Kim et al.		7,118,281 B2	10/2006	Chiu et al.
6,758,600 B2	7/2004	Del Grosso et al.		7,118,405 B2	10/2006	Peng
6,768,860 B2	7/2004	Liberty		7,120,347 B2	10/2006	Blackwell, Jr. et al.
6,771,861 B2	8/2004	Wagner et al.		7,120,348 B2	10/2006	Trebesch et al.
6,773,297 B2	8/2004	Komiya		7,120,349 B2	10/2006	Elliott
6,778,525 B1	8/2004	Baum et al.		7,128,471 B2	10/2006	Wilson
6,778,752 B2	8/2004	Laporte et al.		7,139,462 B1	11/2006	Richtman
6,786,647 B1	9/2004	Hinds et al.		7,171,099 B2	1/2007	Barnes et al.
6,788,871 B2	9/2004	Taylor		7,171,121 B1	1/2007	Skarica et al.
6,792,190 B2	9/2004	Xin et al.		7,181,142 B1	2/2007	Xu et al.
6,798,751 B1	9/2004	Voit et al.		7,193,783 B2	3/2007	Willey et al.
6,804,447 B2	10/2004	Smith et al.		7,194,181 B2	3/2007	Holmberg et al.
6,810,194 B2	10/2004	Griffiths et al.		7,195,521 B2	3/2007	Musolf et al.
6,813,412 B2	11/2004	Lin		7,200,314 B2	4/2007	Womack et al.
6,816,660 B2	11/2004	Nashimoto		7,200,316 B2	4/2007	Giraud et al.
6,819,856 B2	11/2004	Dagley et al.		7,228,036 B2	6/2007	Elkins, II et al.
6,819,857 B2	11/2004	Douglas et al.		7,231,125 B2	6/2007	Douglas et al.
6,826,174 B1	11/2004	Erekson et al.		7,234,878 B2	6/2007	Yamauchi et al.
6,826,346 B2	11/2004	Sloan et al.		7,236,677 B2	6/2007	Escoto et al.
6,839,428 B2	1/2005	Brower et al.		7,245,809 B1	7/2007	Gniadek et al.
6,839,438 B1	1/2005	Riegelsberger et al.		7,259,325 B2	8/2007	Pincu et al.
6,840,815 B2	1/2005	Musolf et al.		7,266,283 B2	9/2007	Kline et al.
6,845,207 B2	1/2005	Schray		7,270,485 B1	9/2007	Robinson et al.
6,848,862 B1	2/2005	Schlig		7,272,291 B2	9/2007	Bayazit et al.
6,850,685 B2	2/2005	Tinucci et al.		7,274,852 B1	9/2007	Smrha et al.
6,853,637 B1	2/2005	Norrell et al.		7,289,731 B2	10/2007	Thinguldstad
6,854,894 B1	2/2005	Yunker et al.		7,292,769 B2	11/2007	Watanabe et al.
6,856,334 B1	2/2005	Fukui		7,298,950 B2	11/2007	Frohlich
6,865,331 B2	3/2005	Mertesdorf		7,300,308 B2	11/2007	Laursen et al.
6,865,334 B2	3/2005	Cooke et al.		7,302,149 B2	11/2007	Swam et al.
6,866,541 B2	3/2005	Barker et al.		7,302,153 B2	11/2007	Thom
6,868,216 B1	3/2005	Gehrke		7,302,154 B2	11/2007	Trebesch et al.
6,869,227 B2	3/2005	Del Grosso et al.		7,308,184 B2	12/2007	Barnes et al.
6,870,734 B2	3/2005	Mertesdorf et al.		7,310,471 B2	12/2007	Bayazit et al.
				7,310,472 B2	12/2007	Haberman

US 8,593,828 B2

Page 5

7,315,681 B2	1/2008	Kewitsch	7,822,310 B2	10/2010	Castonguay et al.	
7,325,975 B2	2/2008	Yamada et al.	7,850,372 B2	12/2010	Nishimura et al.	
7,330,625 B2	2/2008	Barth	7,853,112 B2	12/2010	Zimmel et al.	
7,330,626 B2	2/2008	Kowalczyk et al.	7,856,166 B2	12/2010	Biribuze et al.	
7,330,629 B2	2/2008	Cooke et al.	7,914,332 B2 *	3/2011	Song et al.	439/629
7,331,718 B2	2/2008	Yazaki et al.	7,942,589 B2	5/2011	Yazaki et al.	
7,340,145 B2	3/2008	Allen	7,945,135 B2	5/2011	Cooke et al.	
7,349,615 B2	3/2008	Frazier et al.	7,945,136 B2	5/2011	Cooke et al.	
7,373,071 B2	5/2008	Douglas et al.	7,970,250 B2	6/2011	Morris	
7,376,321 B2	5/2008	Bolster et al.	8,014,171 B2	9/2011	Kelly et al.	
7,376,323 B2	5/2008	Zimmel	8,014,646 B2	9/2011	Keith et al.	
7,391,952 B1	6/2008	Ugolini et al.	8,020,813 B1	9/2011	Clark et al.	
7,397,996 B2	7/2008	Herzog et al.	8,107,785 B2	1/2012	Berglund et al.	
7,400,813 B2	7/2008	Zimmel	8,206,058 B2	6/2012	Vrondran et al.	
7,409,137 B2	8/2008	Barnes	8,537,477 B2	9/2013	Shioda	
7,414,198 B2	8/2008	Stansbie et al.	2001/0010741 A1	8/2001	Hizuka	
7,417,188 B2	8/2008	McNutt et al.	2001/0029125 A1	10/2001	Morita et al.	
7,418,182 B2	8/2008	Krampotich	2002/0010818 A1	1/2002	Wei et al.	
7,418,184 B1	8/2008	Gonzales et al.	2002/0012353 A1	1/2002	Gerszberg et al.	
7,421,182 B2	9/2008	Bayazit et al.	2002/0034290 A1	3/2002	Pershan	
7,428,363 B2	9/2008	Leon et al.	2002/0037139 A1	3/2002	Asao et al.	
7,437,049 B2	10/2008	Krampotich	2002/0064364 A1	5/2002	Batley et al.	
7,439,453 B2	10/2008	Murano et al.	2002/0131730 A1	9/2002	Keeble et al.	
7,454,113 B2	11/2008	Barnes	2002/0136519 A1	9/2002	Tinucci et al.	
7,460,757 B2	12/2008	Hoehne et al.	2002/0141724 A1	10/2002	Ogawa et al.	
7,460,758 B2	12/2008	Xin	2002/0150372 A1	10/2002	Schray	
7,461,981 B2	12/2008	Yow, Jr. et al.	2002/0172467 A1	11/2002	Anderson et al.	
7,462,779 B2	12/2008	Caveney et al.	2002/0181918 A1	12/2002	Spence et al.	
7,463,810 B2	12/2008	Bayazit et al.	2002/0181922 A1	12/2002	Xin et al.	
7,463,811 B2	12/2008	Trebesch et al.	2002/0194596 A1 *	12/2002	Srivastava	725/37
7,469,090 B2	12/2008	Ferris et al.	2003/0007743 A1	1/2003	Asada	
7,471,867 B2	12/2008	Vogel et al.	2003/0007767 A1	1/2003	Douglas et al.	
7,474,828 B2	1/2009	Leon et al.	2003/0021539 A1	1/2003	Kwon et al.	
7,477,824 B2	1/2009	Reagan et al.	2003/0066998 A1	4/2003	Lee	
7,477,826 B2	1/2009	Mullaney et al.	2003/0086675 A1	5/2003	Wu et al.	
7,480,438 B2	1/2009	Douglas et al.	2003/0092396 A1	5/2003	Fifield	455/80
7,488,205 B2	2/2009	Spisany et al.	2003/0095753 A1	5/2003	Wada et al.	
7,493,002 B2	2/2009	Coburn et al.	2003/0147604 A1	8/2003	Tapia et al.	
7,496,269 B1	2/2009	Lee	2003/0174996 A1	9/2003	Henschel et al.	
7,499,622 B2	3/2009	Castonguay et al.	2003/0180012 A1	9/2003	Deane et al.	
7,499,623 B2	3/2009	Barnes et al.	2003/0183413 A1	10/2003	Kato	
7,507,111 B2	3/2009	Togami et al.	2003/0199201 A1	10/2003	Mullaney et al.	
7,509,015 B2	3/2009	Murano	2003/0210882 A1	11/2003	Barthel et al.	
7,509,016 B2	3/2009	Smith et al.	2003/0223723 A1	12/2003	Massey et al.	
7,522,804 B2	4/2009	Araki et al.	2003/0235387 A1	12/2003	Dufour	
7,526,171 B2	4/2009	Caveney et al.	2004/0013389 A1	1/2004	Taylor	
7,526,172 B2	4/2009	Gniadek et al.	2004/0013390 A1	1/2004	Kim et al.	
7,526,174 B2	4/2009	Leon et al.	2004/0074852 A1	4/2004	Knudsen et al.	
7,529,458 B2	5/2009	Spisany et al.	2004/0086238 A1	5/2004	Finona et al.	
7,534,958 B2	5/2009	McNutt et al.	2004/0086252 A1	5/2004	Smith et al.	
7,536,075 B2	5/2009	Zimmel	2004/0147159 A1	7/2004	Urban et al.	
7,542,645 B1	6/2009	Hua et al.	2004/0151465 A1	8/2004	Krampotich et al.	
7,555,193 B2	6/2009	Rapp et al.	2004/0175090 A1	9/2004	Vastmans et al.	
7,558,458 B2	7/2009	Gronvall et al.	2004/0192115 A1	9/2004	Bugg	
7,565,051 B2	7/2009	Vongseng	2004/0208459 A1	10/2004	Mizue et al.	
7,567,744 B2	7/2009	Krampotich et al.	2004/0228598 A1	11/2004	Allen et al.	
7,570,860 B2	8/2009	Smrha et al.	2004/0240882 A1	12/2004	Lipski et al.	
7,570,861 B2	8/2009	Smrha et al.	2004/0264873 A1	12/2004	Smith et al.	
7,577,331 B2	8/2009	Laurisch et al.	2005/0002633 A1	1/2005	Solheid et al.	
7,603,020 B1	10/2009	Wakileh et al.	2005/0008131 A1	1/2005	Cook	
7,607,938 B2	10/2009	Clark et al.	2005/0026497 A1	2/2005	Holliday	
7,609,967 B2	10/2009	Hochbaum et al.	2005/0036749 A1	2/2005	Vogel et al.	
7,613,377 B2	11/2009	Gonzales et al.	2005/0074990 A1	4/2005	Shearman et al.	
7,620,287 B2	11/2009	Appenzeller et al.	2005/0076149 A1	4/2005	McKown et al.	
7,641,398 B2	1/2010	O'Riordan et al.	2005/0083959 A1	4/2005	Binder	
7,668,430 B2	2/2010	McClellan et al.	2005/0107086 A1	5/2005	Tell et al.	
7,668,433 B2	2/2010	Bayazit et al.	2005/0111809 A1	5/2005	Giraud et al.	
7,672,561 B1	3/2010	Keith et al.	2005/0111810 A1	5/2005	Giraud et al.	
7,676,135 B2	3/2010	Chen	2005/0123261 A1	6/2005	Bellekens et al.	
7,697,811 B2	4/2010	Murano et al.	2005/0129379 A1	6/2005	Reagan et al.	
7,715,125 B2	5/2010	Willey	2005/0175293 A1	8/2005	Byers et al.	
7,715,683 B2	5/2010	Kowalczyk et al.	2005/0201073 A1	9/2005	Pincu et al.	
7,740,409 B2	6/2010	Bolton et al.	2005/0232566 A1	10/2005	Rapp et al.	
7,743,495 B2	6/2010	Mori et al.	2005/0233647 A1	10/2005	Denovich et al.	
7,756,382 B2	7/2010	Saravanos et al.	2005/0254757 A1	11/2005	Ferretti, III et al.	
7,760,984 B2	7/2010	Solheid et al.	2005/0281526 A1	12/2005	Vongseng et al.	
7,764,858 B2	7/2010	Bayazit et al.	2006/0007562 A1	1/2006	Willey et al.	
7,809,235 B2	10/2010	Reagan et al.	2006/0018448 A1	1/2006	Stevens et al.	
			2006/0018622 A1	1/2006	Caveney et al.	

US 8,593,828 B2

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2006/0039290	A1	2/2006	Roden et al.	2009/0060439	A1	3/2009	Cox et al.
2006/0044774	A1	3/2006	Vasavda et al.	2009/0060440	A1	3/2009	Wright et al.
2006/0072606	A1	4/2006	Posthuma	2009/0067800	A1	3/2009	Vazquez et al.
2006/0077968	A1	4/2006	Pitsoulakis et al.	2009/0097813	A1	4/2009	Hill
2006/0093303	A1	5/2006	Reagan et al.	2009/0136194	A1	5/2009	Barnes
2006/0110118	A1	5/2006	Escoto et al.	2009/0136196	A1	5/2009	Trebesch et al.
2006/0147172	A1	7/2006	Luther et al.	2009/0146342	A1	6/2009	Haney et al.
2006/0153517	A1	7/2006	Reagan et al.	2009/0148117	A1	6/2009	Laurisch
2006/0160377	A1	7/2006	Huang	2009/0169163	A1	7/2009	Abbott, III et al.
2006/0165365	A1	7/2006	Feustel et al.	2009/0175588	A1	7/2009	Brandt et al.
2006/0165366	A1	7/2006	Feustel et al.	2009/0180749	A1	7/2009	Douglas et al.
2006/0191700	A1	8/2006	Herzog et al.	2009/0185782	A1	7/2009	Parikh et al.
2006/0193590	A1	8/2006	Puetz et al.	2009/0191891	A1	7/2009	Ma et al.
2006/0193591	A1	8/2006	Rapp et al.	2009/0194647	A1	8/2009	Keith
2006/0198098	A1	9/2006	Clark et al.	2009/0196563	A1	8/2009	Mullsteff et al.
2006/0215980	A1	9/2006	Bayazit et al.	2009/0202214	A1	8/2009	Holmberg et al.
2006/0269194	A1	11/2006	Luther et al.	2009/0207577	A1	8/2009	Fransen et al.
2006/0269206	A1	11/2006	Zimmel	2009/0208178	A1	8/2009	Kowalczyk et al.
2006/0269208	A1	11/2006	Allen et al.	2009/0208210	A1	8/2009	Trojer et al.
2006/0275008	A1	12/2006	Xin	2009/0214171	A1	8/2009	Coburn et al.
2006/0275009	A1	12/2006	Ellison et al.	2009/0220200	A1	9/2009	Sheau Tung Wong et al.
2006/0285812	A1	12/2006	Ferris et al.	2009/0220204	A1	9/2009	Ruiz
2007/0003204	A1	1/2007	Makrides-Saravanos et al.	2009/0226142	A1	9/2009	Barnes et al.
2007/0025070	A1	2/2007	Jiang et al.	2009/0238531	A1	9/2009	Holmberg et al.
2007/0031099	A1	2/2007	Herzog et al.	2009/0245743	A1	10/2009	Cote et al.
2007/0033629	A1	2/2007	McGranahan et al.	2009/0252472	A1	10/2009	Solheid et al.
2007/0047894	A1	3/2007	Holmberg et al.	2009/0257726	A1	10/2009	Redmann et al.
2007/0104447	A1	5/2007	Allen	2009/0257727	A1	10/2009	Laurisch et al.
2007/0127201	A1	6/2007	Mertesdorf et al.	2009/0257754	A1	10/2009	Theodoras, II et al.
2007/0131628	A1	6/2007	Mimlitch, III et al.	2009/0263096	A1	10/2009	Solheid et al.
2007/0189692	A1	8/2007	Zimmel et al.	2009/0263122	A1	10/2009	Helkey et al.
2007/0196071	A1	8/2007	Laursen et al.	2009/0267865	A1	10/2009	Miller et al.
2007/0221793	A1	9/2007	Kusuda et al.	2009/0269018	A1	10/2009	Frohlich et al.
2007/0237484	A1	10/2007	Reagan et al.	2009/0274429	A1	11/2009	Krampotich et al.
2007/0274718	A1	11/2007	Bridges et al.	2009/0274430	A1	11/2009	Krampotich et al.
2008/0011514	A1	1/2008	Zheng et al.	2009/0274432	A1	11/2009	Iwaya
2008/0025683	A1	1/2008	Murano	2009/0290842	A1	11/2009	Bran de Leon et al.
2008/0031585	A1	2/2008	Solheid et al.	2009/0297111	A1	12/2009	Reagan et al.
2008/0063350	A1	3/2008	Trebesch et al.	2009/0304342	A1	12/2009	Adomeit et al.
2008/0068788	A1	3/2008	Ozawa et al.	2009/0324189	A1	12/2009	Hill et al.
2008/0069511	A1	3/2008	Blackwell, Jr. et al.	2010/0012671	A1	1/2010	Vrondran et al.
2008/0069512	A1	3/2008	Barnes et al.	2010/0054681	A1	3/2010	Biribuze et al.
2008/0080826	A1	4/2008	Leon et al.	2010/0054682	A1	3/2010	Cooke et al.
2008/0080827	A1	4/2008	Leon et al.	2010/0054685	A1	3/2010	Cooke et al.
2008/0080828	A1	4/2008	Leon et al.	2010/0061691	A1	3/2010	Murano et al.
2008/0085094	A1	4/2008	Krampotich	2010/0061693	A1	3/2010	Bran De Leon et al.
2008/0089656	A1	4/2008	Wagner et al.	2010/0074587	A1	3/2010	Loeffelholz et al.
2008/0095541	A1	4/2008	Dallesasse	2010/0080517	A1	4/2010	Cline et al.
2008/0100440	A1	5/2008	Downie et al.	2010/0086274	A1	4/2010	Keith
2008/0106871	A1	5/2008	James	2010/0111483	A1	5/2010	Reinhardt et al.
2008/0118207	A1	5/2008	Yamamoto et al.	2010/0119201	A1	5/2010	Smrha et al.
2008/0121423	A1	5/2008	Vogel et al.	2010/0142544	A1	6/2010	Chapel et al.
2008/0124039	A1	5/2008	Gniadek et al.	2010/0142910	A1	6/2010	Hill et al.
2008/0131068	A1	6/2008	Mertesdorf et al.	2010/0150518	A1	6/2010	Leon et al.
2008/0145013	A1	6/2008	Escoto et al.	2010/0158467	A1	6/2010	Hou et al.
2008/0152294	A1	6/2008	Hirano et al.	2010/0166377	A1	7/2010	Nair et al.
2008/0166094	A1	7/2008	Bookbinder et al.	2010/0178022	A1	7/2010	Schroeder et al.
2008/0166131	A1	7/2008	Hudgins et al.	2010/0202745	A1	8/2010	Sokolowski et al.
2008/0175550	A1	7/2008	Coburn et al.	2010/0220967	A1	9/2010	Cooke et al.
2008/0175551	A1	7/2008	Smrha et al.	2010/0278499	A1	11/2010	Mures et al.
2008/0175552	A1	7/2008	Smrha et al.	2010/0296790	A1	11/2010	Cooke et al.
2008/0193091	A1	8/2008	Herbst	2010/0310225	A1	12/2010	Anderson et al.
2008/0205823	A1	8/2008	Luther et al.	2010/0310226	A1	12/2010	Wakileh et al.
2008/0205844	A1	8/2008	Castonguay et al.	2010/0316334	A1	12/2010	Kewitsch
2008/0212928	A1	9/2008	Kowalczyk et al.	2010/0322582	A1	12/2010	Cooke et al.
2008/0219632	A1	9/2008	Smith et al.	2010/0322583	A1	12/2010	Cooke et al.
2008/0219634	A1	9/2008	Rapp et al.	2011/0073730	A1	3/2011	Kitchen
2008/0236858	A1	10/2008	Quijano	2011/0085774	A1	4/2011	Murphy et al.
2008/0247723	A1	10/2008	Herzog et al.	2011/0085776	A1	4/2011	Biribuze et al.
2008/0267573	A1	10/2008	Douglas et al.	2011/0097053	A1	4/2011	Smith et al.
2008/0285934	A1	11/2008	Standish et al.	2011/0097977	A1	4/2011	Bubnick et al.
2008/0292261	A1	11/2008	Kowalczyk et al.	2011/0280537	A1	11/2011	Cowen et al.
2008/0298763	A1	12/2008	Appenzeller et al.	2012/0051707	A1	3/2012	Barnes et al.
2008/0304803	A1	12/2008	Krampotich et al.	2012/0183263	A1	7/2012	Wu
2008/0310810	A1	12/2008	Gallagher	2013/0077927	A1	3/2013	O'Connor
2009/0010607	A1	1/2009	Elisson et al.				
2009/0016685	A1	1/2009	Hudgins et al.				
2009/0022470	A1	1/2009	Krampotich				

US 8,593,828 B2

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FOREIGN PATENT DOCUMENTS

CH	688705	A5	1/1998	JP	2004361893	A	12/2004
CN	101801162	A	8/2010	JP	3107704	U	2/2005
DE	8711970	U1	10/1987	JP	2005055748	A	3/2005
DE	3726718	A1	2/1989	JP	2005062569	A	3/2005
DE	3726719	A1	2/1989	JP	2005084241	A	3/2005
DE	4030301	A1	3/1992	JP	2005148327	A	6/2005
DE	4231181	C1	8/1993	JP	3763645	B2	4/2006
DE	10338848	A1	3/2005	JP	3778021	B2	5/2006
DE	202005009932	U1	11/2005	JP	2006126513	A	5/2006
EP	0250900	A2	1/1988	JP	2006126516	A	5/2006
EP	0408266	A2	1/1991	JP	3794540	B2	7/2006
EP	0474091	A1	8/1991	JP	2006227041	A1	8/2006
EP	0468671	A1	1/1992	JP	3833638	B2	10/2006
EP	0490698	A1	6/1992	JP	3841344	B2	11/2006
EP	0529830	A1	3/1993	JP	3847533	B2	11/2006
EP	0544004	A1	6/1993	JP	200747336	A	2/2007
EP	0547778	A1	6/1993	JP	3896035	B2	3/2007
EP	0581527	A1	2/1994	JP	2007067458	A1	3/2007
EP	0620462	A1	10/1994	JP	3934052	B2	6/2007
EP	0693699	A1	1/1996	JP	3964191	B2	8/2007
EP	0720322	A2	7/1996	JP	3989853	B2	10/2007
EP	0940700	A2	9/1999	JP	4026244	B2	12/2007
EP	0949522	A2	10/1999	JP	4029494	B2	1/2008
EP	1041417	A2	10/2000	JP	4065223	B2	3/2008
EP	1065542	A1	1/2001	JP	4093475	B2	6/2008
EP	1203974	A2	5/2002	JP	4105696	B2	6/2008
EP	1316829	A2	6/2003	JP	4112437	B2	7/2008
EP	1777563	A1	4/2007	JP	4118862	B2	7/2008
EP	1968362	A2	9/2008	JP	2008176118	A1	7/2008
FR	2378378	A1	8/1978	JP	2008180817	A1	8/2008
GB	2241591	A	9/1991	JP	4184329	B2	11/2008
GB	2277812	A	11/1994	JP	2008542822	T	11/2008
JP	3172806	A	7/1991	JP	2009503582	T	1/2009
JP	5045541	A	2/1993	WO	9105281	A1	4/1991
JP	06018749	A	1/1994	WO	9326070	A1	12/1993
JP	7308011	A	11/1995	WO	9520175	A1	7/1995
JP	8007308	A	1/1996	WO	9712268	A1	4/1997
JP	8248235	A	9/1996	WO	9744605	A1	11/1997
JP	8248237	A	9/1996	WO	9825416	A1	6/1998
JP	3487946	A	10/1996	WO	0005611	A2	2/2000
JP	8254620	A	10/1996	WO	0127660	A2	4/2001
JP	3279474	A	10/1997	WO	0242818	A1	5/2002
JP	9258033	A	10/1997	WO	03009527	A2	1/2003
JP	9258055	A	10/1997	WO	2004052066	A1	6/2004
JP	2771870	B2	7/1998	WO	2007050515	A1	5/2007
JP	3448448	A	8/1998	WO	2007079074	A2	7/2007
JP	10227919	A	8/1998	WO	2007149215	A2	12/2007
JP	3478944	A	12/1998	WO	2008063054	A2	5/2008
JP	10339817	A	12/1998	WO	2008/130341	A1	10/2008
JP	11023858	A	1/1999	WO	2009120280	A2	10/2009
JP	2000098138	A	4/2000	OTHER PUBLICATIONS			
JP	2000098139	A	4/2000	Annex to Form PCT/ISA/206, Communication Relating to the			
JP	2000241631	A	9/2000	Results of the Partial International Search, for PCT/US2009/004548			
JP	2001004849	A	1/2001	mailed Jan. 19, 2010, 2 pages.			
JP	3160322	B2	4/2001	Corning Cable Systems, "Corning Cable Systems Products for			
JP	2001133636	A	5/2001	BellSouth High Density Shelves," Jun. 2000, 2 pages.			
JP	3173962	B2	6/2001	Corning Cable Systems, "Corning Cable Systems Quick Reference			
JP	3176906	B2	6/2001	Guide for Verizon FTTP FDH Products," Jun. 2005, 4 pages.			
JP	2001154030	A	6/2001	Conner, M. "Passive Optical Design for RFOG and Beyond,"			
JP	2001159714	A	6/2001	Broadband Properties, Apr. 2009, pp. 78-81.			
JP	2002022974	A	1/2002	Corning Evolant, "Eclipse Hardware Family," Nov. 2009, 1 page.			
JP	2002169035	A	6/2002	Corning Evolant, "Enhanced Management Frame," Dec. 2009, 1			
JP	3312893	B2	8/2002	page.			
JP	2002305389	A	10/2002	Corning Evolant, "Enhanced Management Frame (EMF)," Specifi-			
JP	3344701	B2	11/2002	cation Sheet, Nov. 2009, 24 pages.			
JP	2003029054	A	1/2003	Corning Cable Systems, "Evolant Solutions for Evolving Networks:			
JP	3403573	B2	5/2003	Fiber Optic Hardware," Oct. 2002, 2 pages.			
JP	2003169026	A	6/2003	Corning Cable Systems, "Fiber Optic Hardware with Factory-In-			
JP	2003215353	A	7/2003	stalled Pigtailed: Features and Benefits," Nov. 2010, 12 pages.			
JP	2003344701	A	12/2003	Corning Cable Systems, "FiberManager System 1- and 3-Position			
JP	3516765	B2	4/2004	Compact Shelves," Jan. 2003, 4 pages.			
JP	2004144808	A	5/2004	Corning Cable Systems, "FiberManager System Frame and Compo-			
JP	2004514931	A	5/2004	nents," Jan. 2003, 12 pages.			
JP	3542939	B2	7/2004	Corning Cable Systems, "High Density Frame," Jul. 2001, 2 pages.			
JP	2004246147	A	9/2004				
JP	2004361652	A	12/2004				

US 8,593,828 B2

Page 8

(56)

References Cited**OTHER PUBLICATIONS**

Corning Cable Systems, "High Density Frame (HDF) Connector-Splice Shelves and Housings," May 2003, 4 pages.

International Search Report for PCT/US10/35529 mailed Jul. 23, 2010, 2 pages.

International Search Report for PCT/US10/35563 mailed Jul. 23, 2012, 1 page.

International Search Report for PCT/US2008/002514 mailed Aug. 8, 2008, 2 pages.

International Search Report for PCT/US2008/010317 mailed Mar. 4, 2008, 2 pages.

International Search Report for PCT/US2009/001692 mailed Nov. 24, 2009, 5 pages.

International Search Report for PCT/US2010/024888 mailed Jun. 23, 2010, 5 pages.

International Search Report for PCT/US2010/027402 mailed Jun. 16, 2010, 2 pages.

Corning Cable Systems, "MTX Frames and Accessories," Feb. 2006, 4 pages.

Panduit, "Lock-in LC Duplex Clip," Accessed Mar. 22, 2012, 1 page.

International Search Report for PCT/US06/49351 mailed Apr. 25, 2008, 1 page.

International Search Report for PCT/US09/57069 mailed Mar. 24, 2010, 2 pages.

International Search Report for PCT/US2009/057244 mailed Nov. 9, 2009, 3 pages.

International Search Report for PCT/US2009/004548 mailed Mar. 19, 2010, 5 pages.

International Search Report for PCT/US2009/004549 mailed Apr. 20, 2010, 6 pages.

Siecor, "Single Shelf HDF with Slack Storage and Heat Shield (HH1-CSH-1238-1V-BS)," Jan. 1998, 12 pages.

Corning Cable Systems, "Mass Termination Xchange (MTX) Frame System Equipment Office Planning and Application Guide," SRP003-664, Issue 1, Mar. 2005, 57 pages.

Corning Cable Systems, "Mass Termination Xchange (MTX) Equipment Patch Cord Interbay Vertical Channel," SRP003-684, Issue 1, Mar. 2005, 8 pages.

Corning Cable Systems, "High Density Frame (HDF) Installation," SRP003-355, Issue 4, Sep. 2002, 18 pages.

Written Opinion for PCT/US2010/023901 mailed Aug. 25, 2011, 8 pages.

Advisory Action for U.S. Appl. No. 12/221,117 mailed Aug. 24, 2011, 3 pages.

Examiner's Answer to Appeal Brief for U.S. Appl. No. 12/221,117 mailed Mar. 29, 2012, 16 pages.

Final Office Action for U.S. Appl. No. 12/221,117 mailed Feb. 19, 2010, 7 pages.

Final Office Action for U.S. Appl. No. 12/221,117 mailed Jun. 10, 2011, 8 pages.

Non-final Office Action for U.S. Appl. No. 12/221,117 mailed Jul. 14, 2010, 7 pages.

Non-final Office Action for U.S. Appl. No. 12/221,117 mailed Jun. 9, 2009, 5 pages.

Non-final Office Action for U.S. Appl. No. 12/221,117 mailed Dec. 21, 2010, 7 pages.

Advisory Action for U.S. Appl. No. 12/394,483 mailed Feb. 16, 2012, 3 pages.

Final Office Action for U.S. Appl. No. 12/394,483 mailed Dec. 6, 2011, 14 pages.

Non-final Office Action for U.S. Appl. No. 12/394,483 mailed Jun. 17, 2011, 11 pages.

Advisory Action for U.S. Appl. No. 12/950,234 mailed Dec. 21, 2011, 3 pages.

Non-final Office Action for U.S. Appl. No. 12/950,234 mailed Jun. 17, 2011, 7 pages.

Non-final Office Action for U.S. Appl. No. 12/950,234 mailed Mar. 12, 2012, 10 pages.

Final Office Action for U.S. Appl. No. 12/950,234 mailed Oct. 14, 2011, 10 pages.

Advisory Action mailed May 12, 2011, for U.S. Appl. No. 12/323,423, 3 pages.

Final Rejection mailed Mar. 3, 2011, for U.S. Appl. No. 12/323,423, 17 pages.

Non-Final Rejection mailed Aug. 5, 2011, for U.S. Appl. No. 12/323,423, 13 pages.

Non-Final Rejection mailed Sep. 7, 2010, for U.S. Appl. No. 12/323,423, 18 pages.

Notice of Allowance for U.S. Appl. No. 12/323,423 mailed Jan. 24, 2012, 8 pages.

Examiner's Answer mailed Mar. 4, 2011, for U.S. Appl. No. 12/323,415, 11 pages.

Final Rejection mailed Jun. 25, 2010, for U.S. Appl. No. 12/323,415, 10 pages.

Non-Final Rejection mailed Aug. 5, 2011, for U.S. Appl. No. 12/323,415, 41 pages.

Non-final Office Action for U.S. Appl. No. 12/323,415 mailed Apr. 23, 2012, 11 pages.

Non-Final Rejection mailed Dec. 10, 2009, for U.S. Appl. No. 12/323,415, 7 pages.

Examiner's Answer to Appeal Brief for U.S. Appl. No. 11/320,062 mailed Dec. 8, 2011, 8 pages.

Final Office Action for U.S. Appl. No. 11/320,062 mailed Mar. 8, 2011, 8 pages.

Non-final Office Action for U.S. Appl. No. 11/320,062 mailed Jan. 15, 2010, 11 pages.

Non-final Office Action for U.S. Appl. No. 12/320,062 mailed Sep. 30, 2010, 7 pages.

Final Office Action for U.S. Appl. No. 11/439,086 mailed Feb. 4, 2010, 14 pages.

Non-final Office Action for U.S. Appl. No. 11/439,086 mailed May 3, 2010, 11 pages.

Non-final Office Action for U.S. Appl. No. 11/439,086 mailed Sep. 21, 2009, 10 pages.

Final Office Action for U.S. Appl. No. 12/079,481 mailed Mar. 18, 2010, 10 pages.

Non-final Office Action for U.S. Appl. No. 12/079,481 mailed Dec. 26, 2008, 9 pages.

Non-final Office Action for U.S. Appl. No. 12/079,481 mailed Sep. 16, 2009, 10 pages.

Notice of Allowance for U.S. Appl. No. 12/079,481 mailed Jun. 3, 2010, 6 pages.

Notice of Allowance for U.S. Appl. No. 12/079,481 mailed Oct. 4, 2010, 4 pages.

Final Office Action for U.S. Appl. No. 12/394,114 mailed Dec. 22, 2011, 8 pages.

Non-final Office Action for U.S. Appl. No. 12/394,114 mailed Mar. 16, 2012, 8 pages.

Non-final Office Action for U.S. Appl. No. 12/394,114 mailed Sep. 1, 2011, 7 pages.

Non-final Office Action for U.S. Appl. No. 12/323,373 mailed May 3, 2012, 7 pages.

Non-final Office Action for U.S. Appl. No. 11/809,474 mailed Apr. 8, 2008, 13 pages.

Non-final Office Action for U.S. Appl. No. 11/809,474 mailed Nov. 13, 2008, 10 pages.

Notice of Allowance for U.S. Appl. No. 11/809,474 mailed Jul. 6, 2009, 6 pages.

Final Office Action for U.S. Appl. No. 11/320,031 mailed Mar. 8, 2011, 8 pages.

Non-final Office Action for U.S. Appl. No. 11/320,031 mailed Jan. 5, 2010, 16 pages.

Non-final Office Action for U.S. Appl. No. 11/320,031 mailed Sep. 30, 2010, 7 pages.

Notice of Allowance for U.S. Appl. No. 11/320,031 mailed Nov. 15, 2011, 7 pages.

Non-final Office Action for U.S. Appl. No. 12/157,622 mailed Mar. 31, 2009, 9 pages.

Non-final Office Action for U.S. Appl. No. 12/157,622 mailed Oct. 15, 2009, 9 pages.

Notice of Allowance for U.S. Appl. No. 12/157,622 mailed Apr. 22, 2010, 4 pages.

US 8,593,828 B2

Page 9

(56)

References Cited

OTHER PUBLICATIONS

Non-final Office Action for U.S. Appl. No. 12/323,395 mailed Dec. 8, 2011, 7 pages.

Non-final Office Action for U.S. Appl. No. 12/415,454 mailed Mar. 2, 2012, 5 pages.

Non-final Office Action for U.S. Appl. No. 12/415,454 mailed Sep. 6, 2011, 7 pages.

Notice of Allowance for U.S. Appl. No. 12/415,454 mailed Jan. 13, 2012, 5 pages.

Non-final Office Action for U.S. Appl. No. 12/576,769 mailed Feb. 2, 2012, 23 pages.

Notice of Allowance for U.S. Appl. No. 12/415,454 mailed Jun. 19, 2012, 5 pages.

International Search Report for PCT/US2010/023901 mailed Jun. 11, 2010, 3 pages.

Notice of Allowance for U.S. Appl. No. 12/576,769 mailed May 31, 2012, 9 pages.

Non-final Office Action for U.S. Appl. No. 12/576,806 mailed Dec. 13, 2011, 6 pages.

Notice of Allowance for U.S. Appl. No. 12/576,806 mailed Apr. 18, 2012, 5 pages.

Unknown, Author, "QuickNet SFQ Series MTP Fiber Optic Cassettes," Panduit Specification Sheet, Jan. 2009, 2 pages.

Unknown Author, "Cellular Specialties introduces the first simulated in-building location-based tracking solution," smart-grid.tmenet.com/news, Sep. 14, 2009, 2 pages.

Unknown Author, "CDMA Co-Pilot Transmitter," Cellular Specialties, Inc., Aug. 2009, 2 pages.

International Search Report for PCT/US2010/038986 mailed Aug. 18, 2010, 1 page.

International Search Report for PCT/US2009/066779 mailed Aug. 27, 2010, 3 pages.

"MPO Fiber Optic Rack Panels now available from L-com Connectivity Products," article dated Jun. 4, 2007, 16 pages, <http://www.l-com.com/content/Article.aspx?Type=P&ID=438>.

'19' Rack Panel with 16 MPO Fiber Optic Couplers—IU high, product page, accessed Oct. 23, 2012, 2 pages, <http://www.l-com.com/item.aspx?id=9767#.UlbgG8XXay5>.

"Drawing for L-com IU Panel with 16 MTP couplers," May 15, 2007, 1 page, http://www.l-com.com/multimedia/eng_drawings/PR17516MTP.pd.

"RapidNet Fibre MTP VHD Cassette," Brochure, Date Unknown, 1 page, http://www.hellermanntyton.se/documents/5000/5762_fiber_IU.pdf.

"MPO for Gigabit Ethernet/FAS-NET MTP Solution," Brochure, Date Unknown, 11 pages, <http://www.infinique.com/upload/13182286190.pdf>.

"Hubbell OptiChannel High Density 144 Port IU Fiber Enclosure," Brochure, Date Unknown, 2 pages, <http://www.hubbell-premise.com/literature/PLDF010.pdf>.

Non-final Office Action for U.S. Appl. No. 12/771,473 mailed Oct. 4, 2012, 6 pages.

Non-final Office Action for U.S. Appl. No. 12/819,081 mailed Aug. 21, 2012, 12 pages.

Notice of Allowance for U.S. Appl. No. 12/417,325 mailed Aug. 22, 2012, 7 pages.

Notice of Panel Decision for Pre-Appeal Brief for U.S. Appl. No. 12/417,325 mailed Aug. 8, 2012, 2 pages.

Advisory Action for U.S. Appl. No. 12/417,325 mailed Jun. 29, 2012, 3 pages.

Advisory Action for U.S. Appl. No. 12/417,325 mailed Jun. 12, 2012, 3 pages.

Final Office Action for U.S. Appl. No. 12/417,325 mailed Apr. 16, 2012, 6 pages.

Final Office Action for U.S. Appl. No. 12/417,325 mailed Feb. 7, 2012, 7 pages.

Non-final Office Action for U.S. Appl. No. 12/417,325 mailed Jun. 15, 2011, 6 pages.

Notice of Allowance for U.S. Appl. No. 12/487,929 mailed Sep. 12, 2012, 4 pages.

Notice of Allowance for U.S. Appl. No. 12/487,929 mailed Jun. 13, 2012, 8 pages.

Advisory Action for U.S. Appl. No. 12/487,929 mailed Apr. 17, 2012, 3 pages.

Final Office Action for U.S. Appl. No. 12/487,929 mailed Feb. 14, 2012, 6 pages.

Final Office Action for U.S. Appl. No. 12/487,929 mailed Dec. 5, 2011, 7 pages.

Non-final Office Action for U.S. Appl. No. 12/487,929 mailed May 23, 2011, 7 pages.

Notice of Allowance for U.S. Appl. No. 12/415,253 mailed Mar. 11, 2011, 7 pages.

Non-final Office Action for U.S. Appl. No. 12/415,253 mailed Jul. 12, 2010, 11 pages.

Final Office Action for U.S. Appl. No. 12/415,253 mailed Apr. 16, 2010, 9 pages.

Non-final Office Action for U.S. Appl. No. 12/415,253 mailed Sep. 30, 2009, 8 pages.

Non-final Office Action for U.S. Appl. No. 12/641,617 mailed Oct. 5, 2012, 21 pages.

Final Office Action for U.S. Appl. No. 12/630,938 mailed Jun. 1, 2012, 18 pages.

Non-final Office Action for U.S. Appl. No. 12/630,938 mailed Dec. 19, 2011, 15 pages.

Non-final Office Action for U.S. Appl. No. 12/751,884 mailed Jul. 2, 2012, 9 pages.

Non-final Office Action for U.S. Appl. No. 12/871,052 mailed Aug. 13, 2012, 8 pages.

European Patent Office Search Report for Application No. 11000757.2-1237, dated Jun. 6, 2011, 6 pages.

Non-Final Office Action for U.S. Appl. No. 12/707,889 mailed Jan. 2, 2013, 7 pages.

Non-Final Office Action for U.S. Appl. No. 12/953,536 mailed Jan. 2, 2013, 20 pages.

Non-Final Office Action for U.S. Appl. No. 12/953,039 mailed Jan. 11, 2013, 6 pages.

Non-Final Office Action for U.S. Appl. No. 12/952,912 mailed Dec. 28, 2012, 9 pages.

Non-Final Office Action for U.S. Appl. No. 12/953,118 mailed Jan. 7, 2013, 9 pages.

Final Office Action for U.S. Appl. No. 12/394,114 mailed Oct. 25, 2012, 8 pages.

Non-final Office Action for U.S. Appl. No. 12/732,487 mailed Sep. 19, 2012, 22 pages.

Non-final Office Action for U.S. Appl. No. 12/818,986 mailed Feb. 3, 2012, 12 pages.

Final Office Action for U.S. Appl. No. 12/818,986 mailed Oct. 18, 2012, 13 pages.

Non-final Office Action for U.S. Appl. No. 12/952,960 mailed Oct. 4, 2012, 11 pages.

Non-final Office Action for U.S. Appl. No. 12/953,134 mailed Sep. 25, 2012, 8 pages.

Non-final Office Action for U.S. Appl. No. 12/915,682 mailed Oct. 24, 2012, 8 pages.

Non-final Office Action for U.S. Appl. No. 12/946,139 mailed Jul. 26, 2012, 12 pages.

Final Office Action for U.S. Appl. No. 12/946,139 mailed Feb. 15, 2013, 17 pages.

Non-final Office Action for U.S. Appl. No. 12/394,114 mailed Feb. 27, 2013, 8 pages.

Non-final Office Action for U.S. Appl. No. 12/819,065 mailed Mar. 4, 2013, 7 pages.

Final Office Action for U.S. Appl. No. 12/952,960 mailed Mar. 7, 2013, 13 pages.

Notice of Allowance for U.S. Appl. No. 12/732,487 mailed Mar. 19, 2013, 11 pages.

Non-final Office Action for U.S. Appl. No. 12/953,134 mailed Mar. 21, 2013, 9 pages.

Final Office Action for U.S. Appl. No. 12/641,617 mailed May 10, 2013, 21 pages.

European Search Report for patent application 10790017.7 mailed Nov. 8, 2012, 7 pages.

US 8,593,828 B2

Page 10

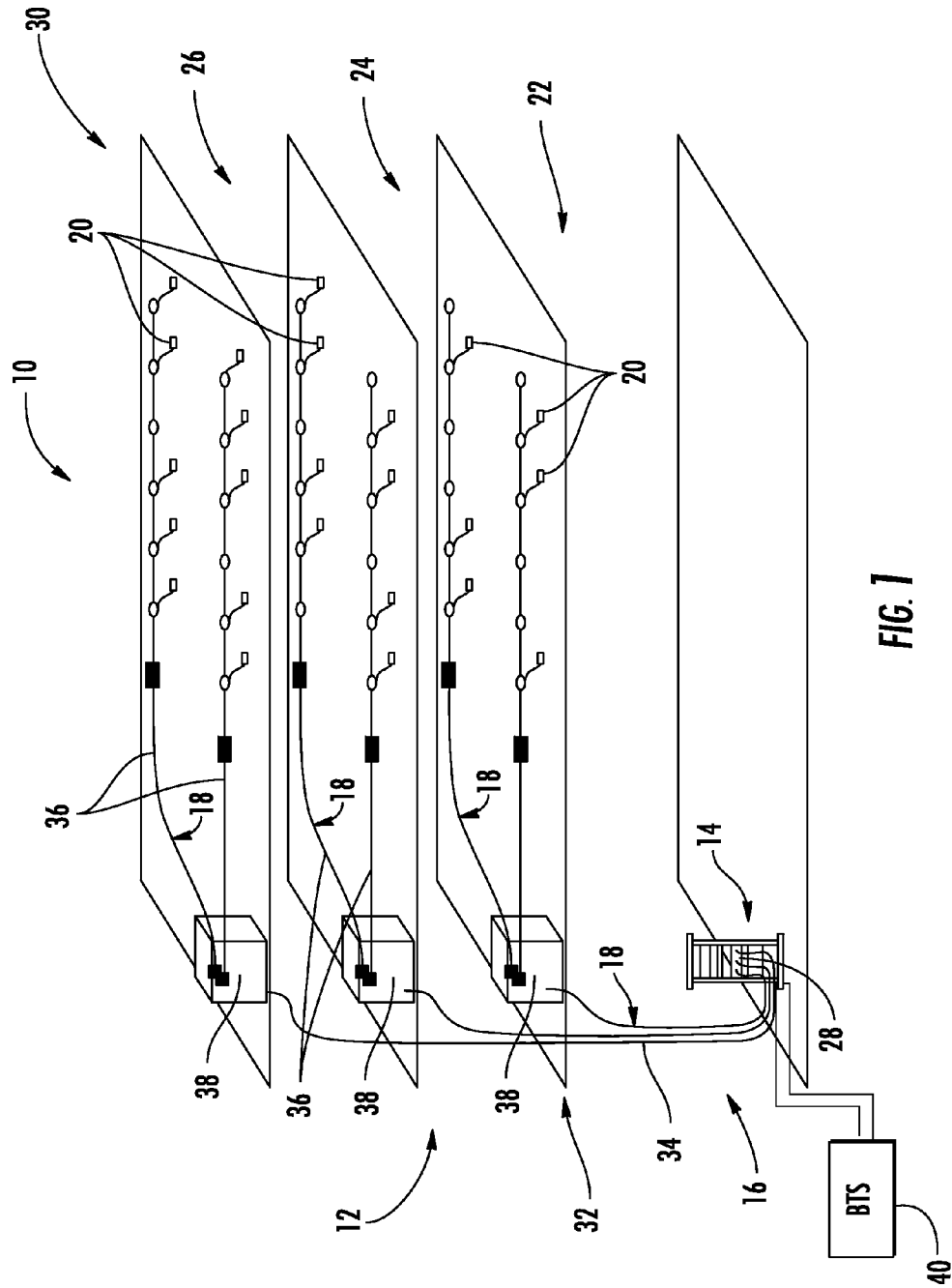
(56)

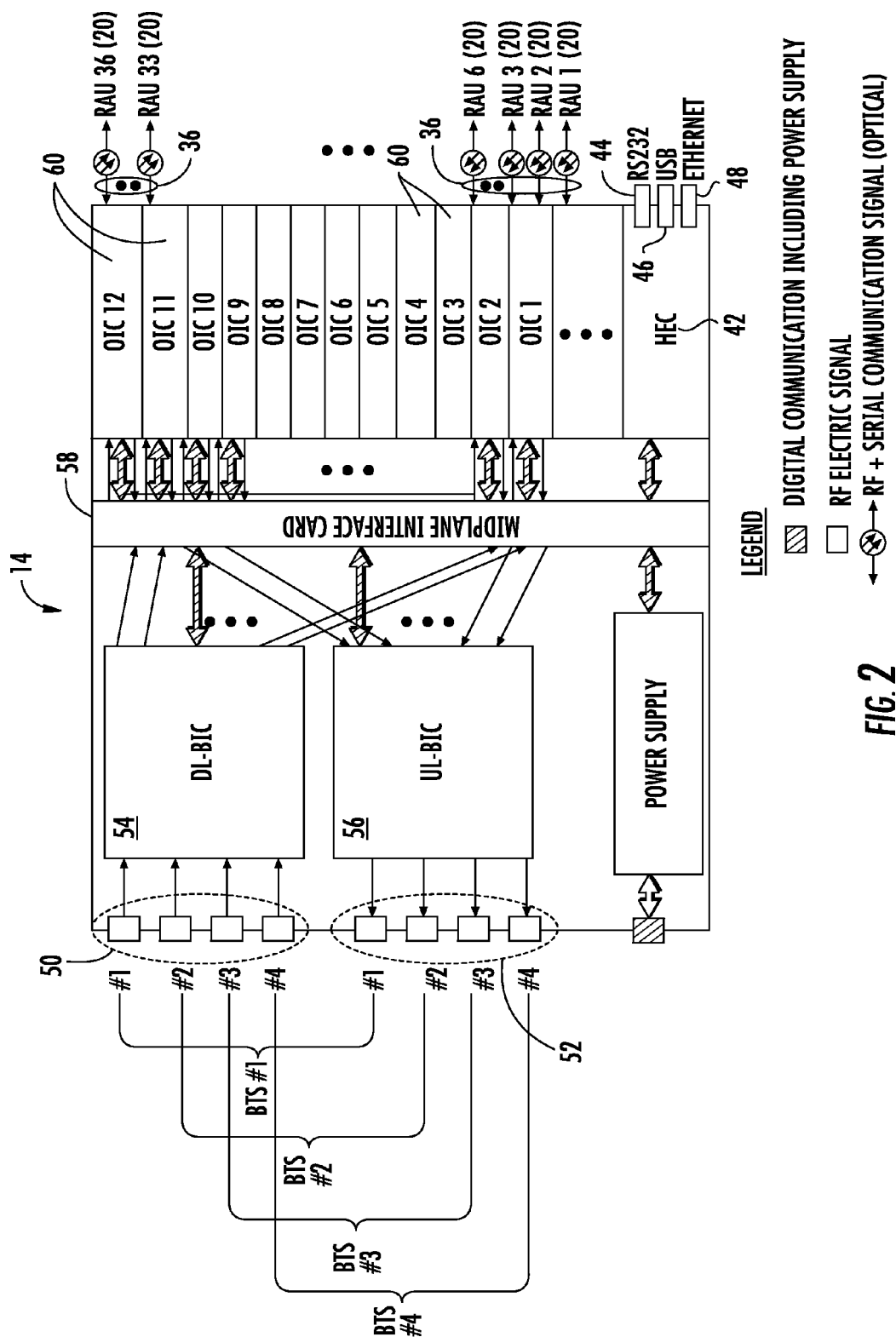
References Cited**OTHER PUBLICATIONS**

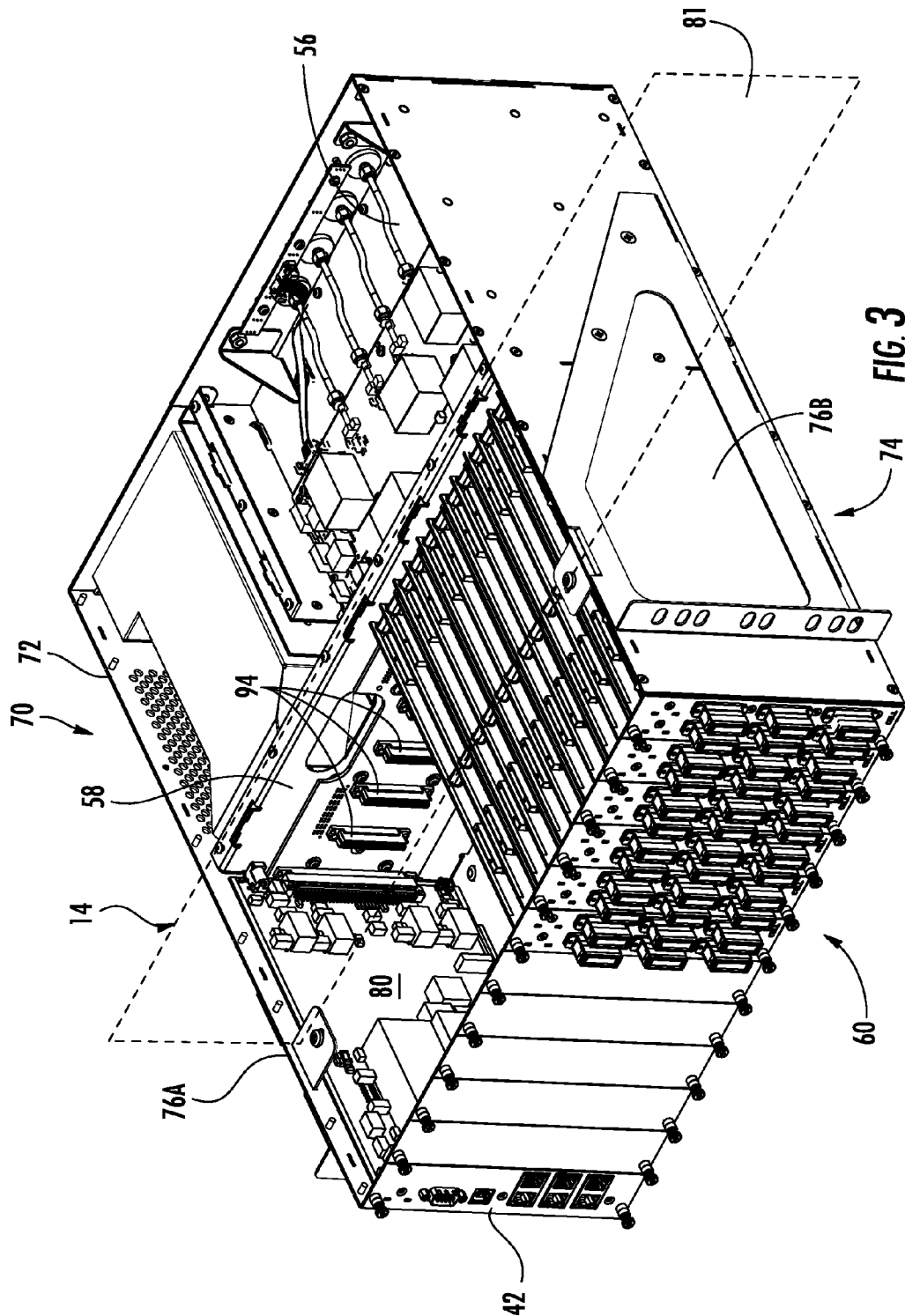
Notice of Allowance for U.S. Appl. No. 13/090,621 mailed Apr. 22, 2013, 8 pages.
 Final Office Action for U.S. Appl. No. 12/953,039 mailed May 1, 2013, 8 pages.
 Final Office Action for U.S. Appl. No. 12/953,118 mailed May 3, 2013, 11 pages.
 Final Office Action for U.S. Appl. No. 12/915,682 mailed Apr. 18, 2013, 9 pages.
 Advisory Action for U.S. Appl. No. 12/952,960 mailed May 15, 2013, 2 pages.
 Non-final Office Action for U.S. Appl. No. 12/952,960 mailed Jun. 20, 2013, 13 pages.
 Non-final Office Action for U.S. Appl. No. 12/953,536 mailed Jun. 6, 2013, 21 pages.
 Non-final Office Action for U.S. Appl. No. 11/820,300 mailed Apr. 25, 2012, 10 pages.
 Final Office Action for U.S. Appl. No. 12/871,052 mailed Jul. 1, 2013, 12 pages.
 Non-final Office Action for U.S. Appl. No. 12/940,699 mailed Jun. 26, 2013, 9 pages.
 Notice of Allowance for U.S. Appl. No. 13/090,621 mailed Jun. 25, 2013, 8 pages.
 Non-final Office Action for U.S. Appl. No. 13/302,067 mailed Jun. 7, 2013, 13 pages.
 Final Office Action for U.S. Appl. No. 12/771,473 mailed Jul. 19, 2013, 7 pages.
 Non-final Office Action for U.S. Appl. No. 12/940,585 mailed Aug. 16, 2013, 14 pages.

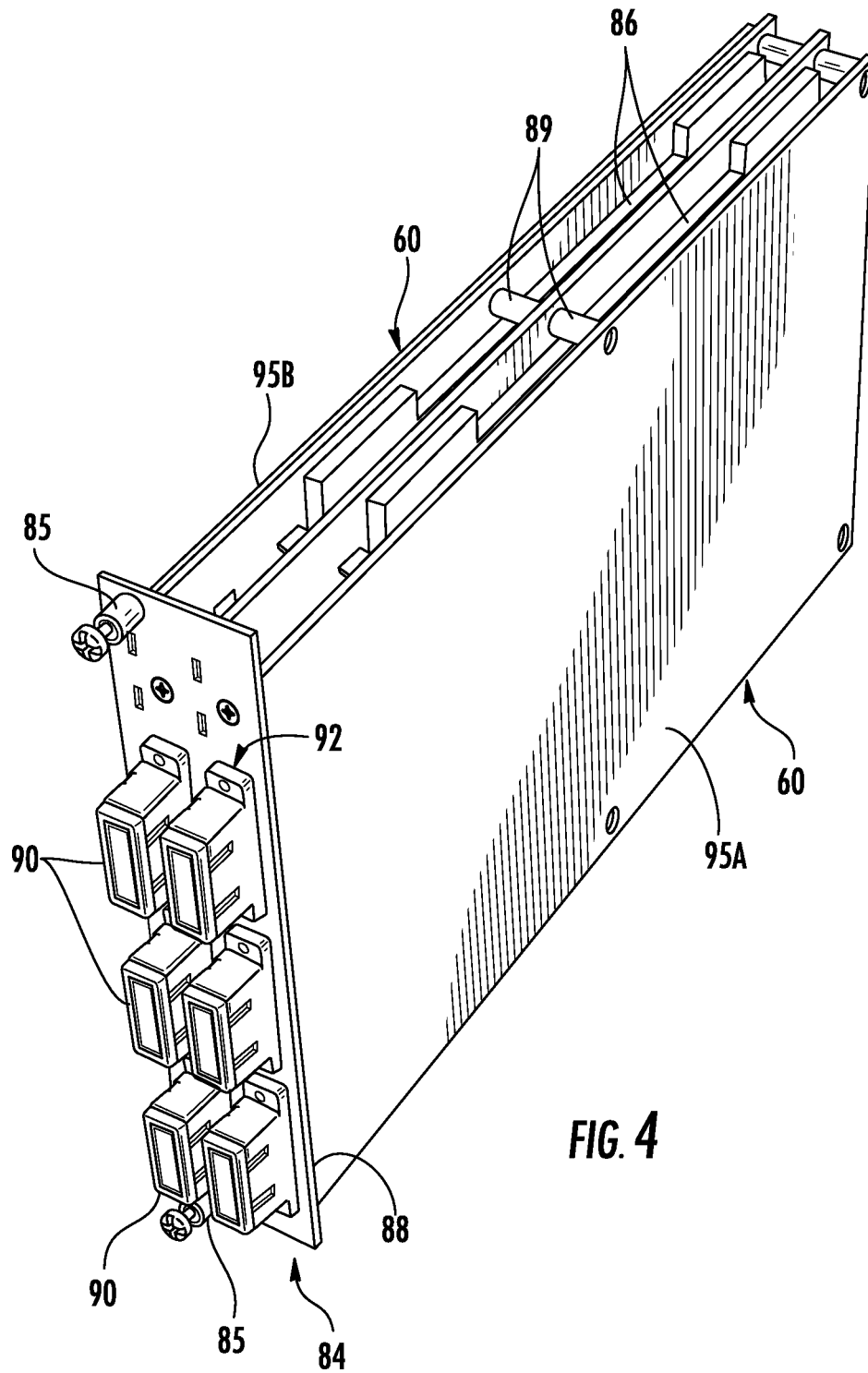
Final Office Action for U.S. Appl. No. 12/953,134 mailed Aug. 23, 2013, 11 pages.
 Ex parte Quayle Action for U.S. Appl. No. 12/953,164 mailed Aug. 16, 2013, 5 pages.
 Non-final Office Action for U.S. Appl. No. 12/732,487 mailed Jul. 17, 2013, 22 pages.
 Non-final Office Action and Interview Summary for U.S. Appl. No. 12/707,889 mailed Aug. 8, 2013, 15 pages.
 Advisory Action for U.S. Appl. No. 12/953,039 mailed Jul. 12, 2013, 3 pages.
 Advisory Action for U.S. Appl. No. 12/953,118 mailed Jul. 12, 2013, 3 pages.
 Advisory Action for U.S. Appl. No. 12/641,617 mailed Jul. 29, 2013, 3 pages.
 Final Office Action for U.S. Appl. No. 12/952,912 mailed Aug. 30, 2013, 15 pages.
 Advisory Action for U.S. Appl. No. 12/771,473 mailed Oct. 2, 2013, 3 pages.
 Notice of Allowance for U.S. Appl. No. 12/641,617 mailed Sep. 4, 2013, 9 pages.
 Notice of Allowance for U.S. Appl. No. 12/871,052 mailed Sep. 18, 2013, 9 pages.
 Non-final Office Action for U.S. Appl. No. 12/953,039 mailed Sep. 12, 2013, 8 pages.
 Non-final Office Action for U.S. Appl. No. 12/946,139 mailed Oct. 2, 2013, 18 pages.
 Final Office Action for U.S. Appl. No. 12/394,114 mailed Oct. 4, 2013, 10 pages.
 Non-final Office Action for U.S. Appl. No. 12/818,986 mailed Oct. 4, 2013, 19 pages.

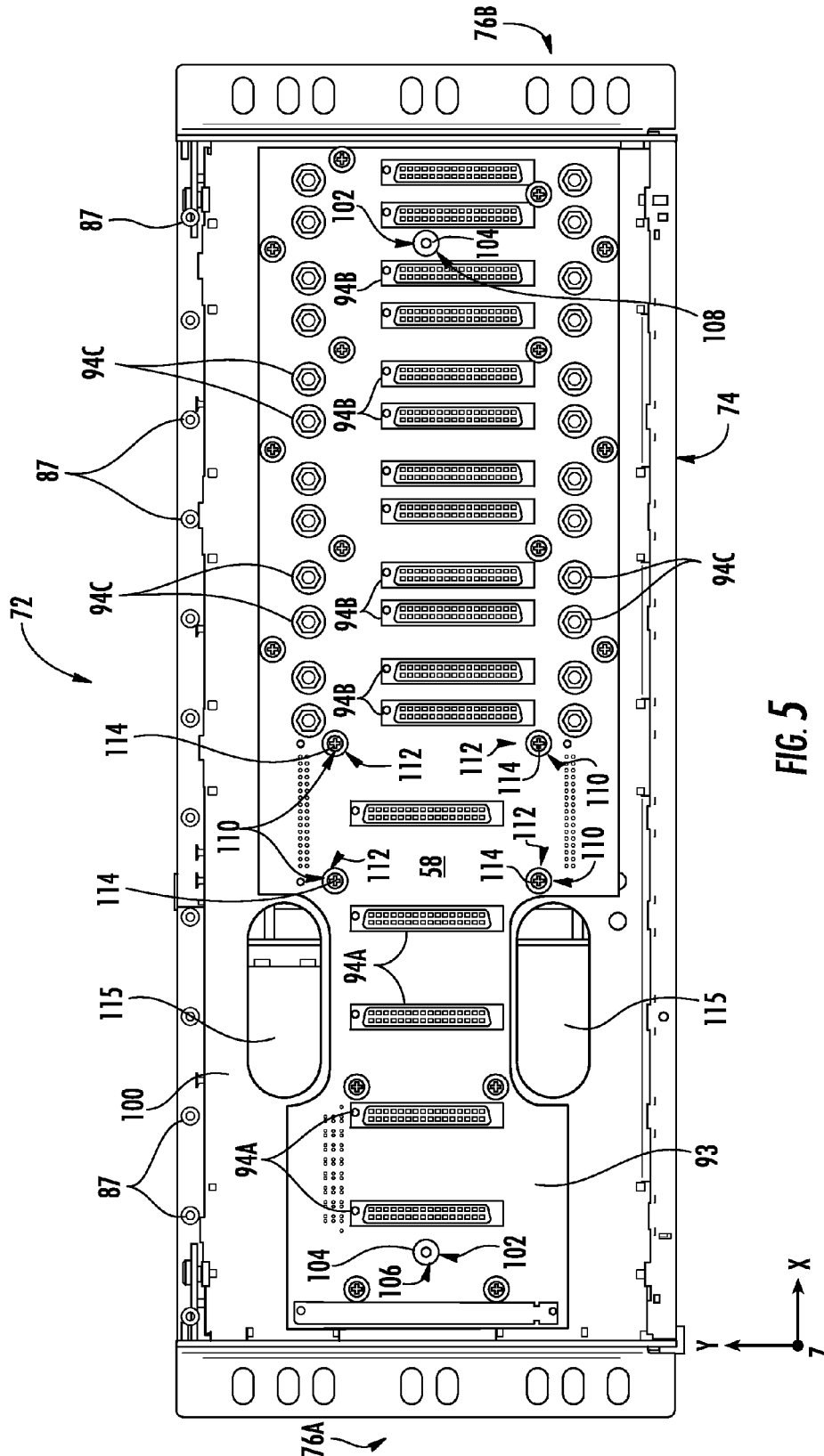
* cited by examiner

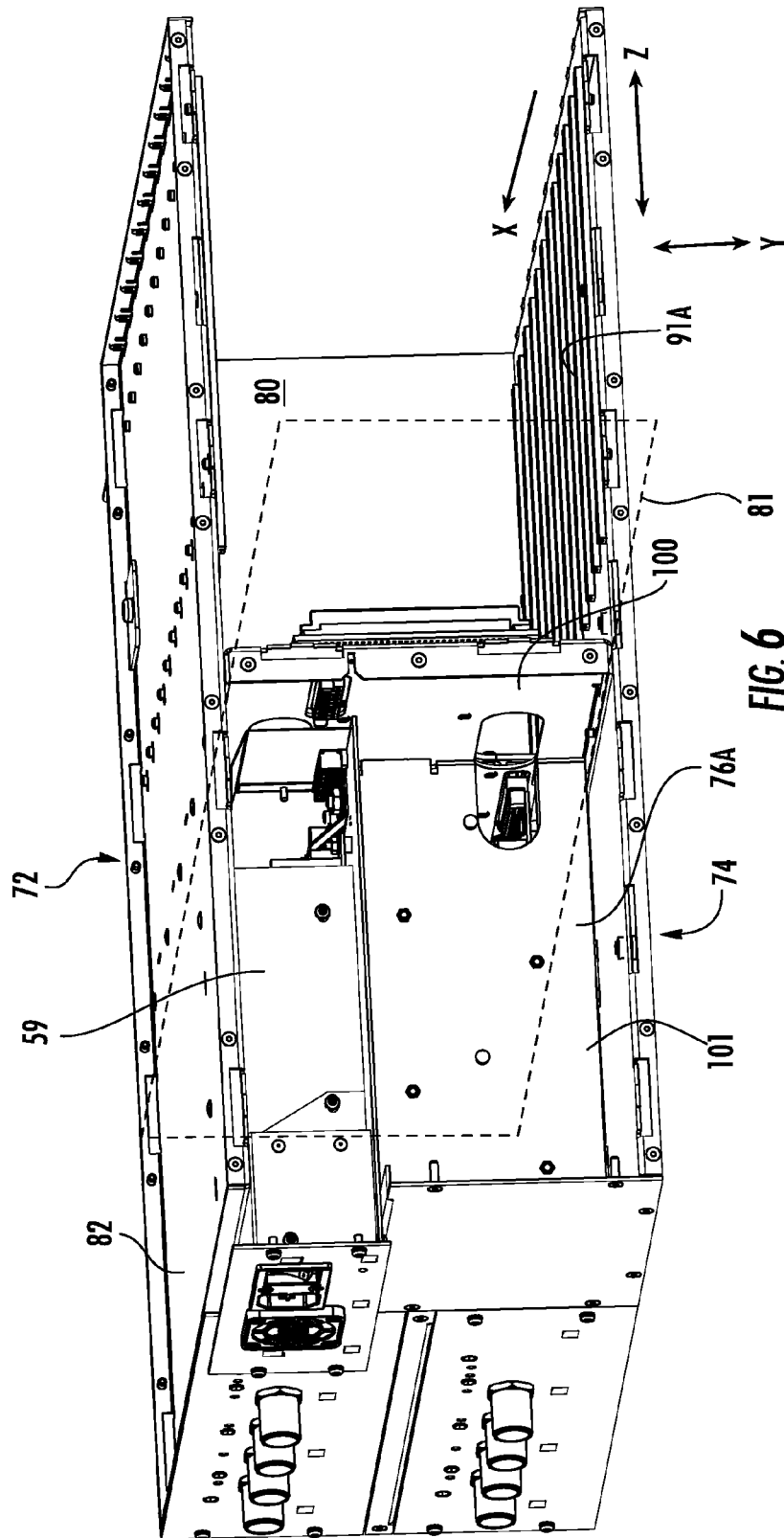


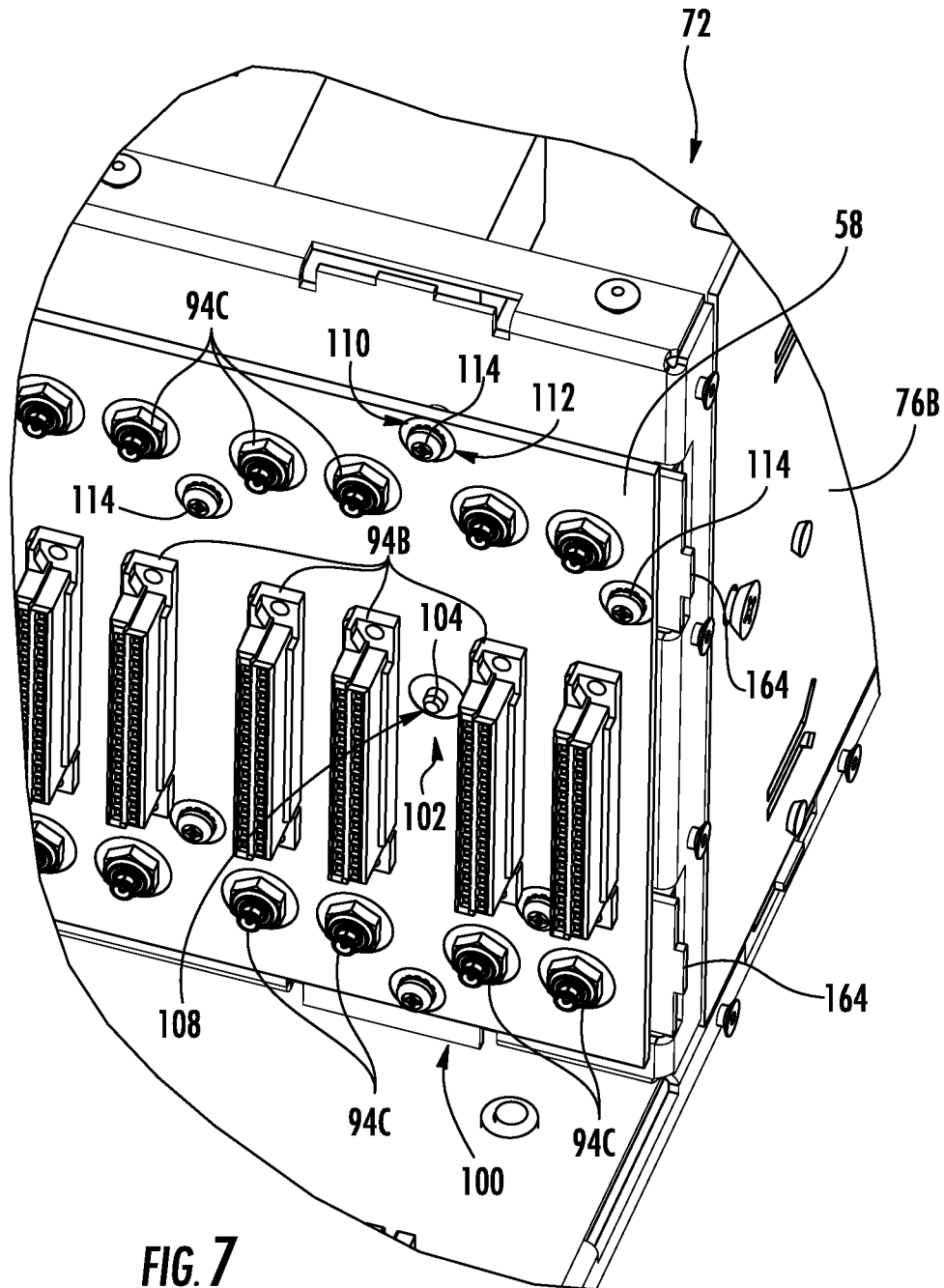


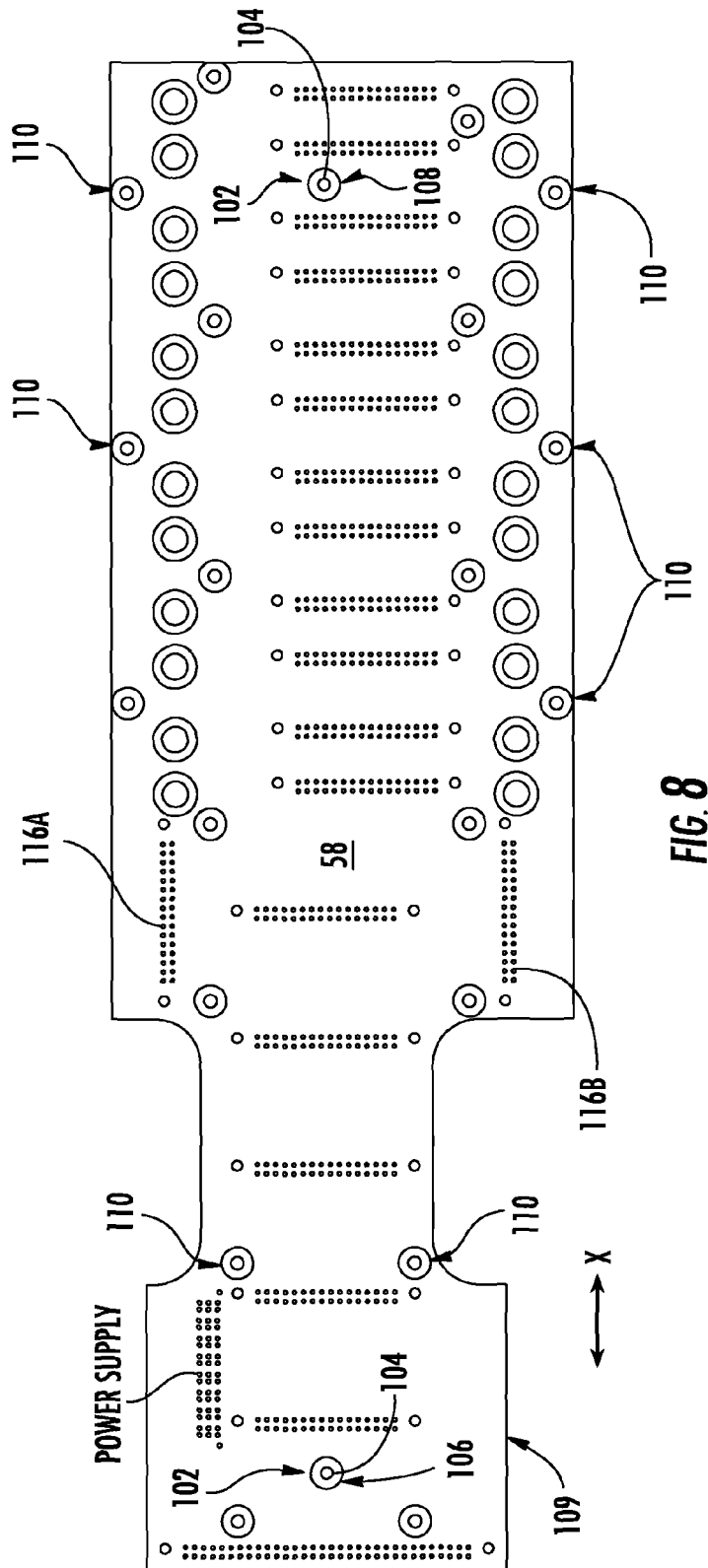












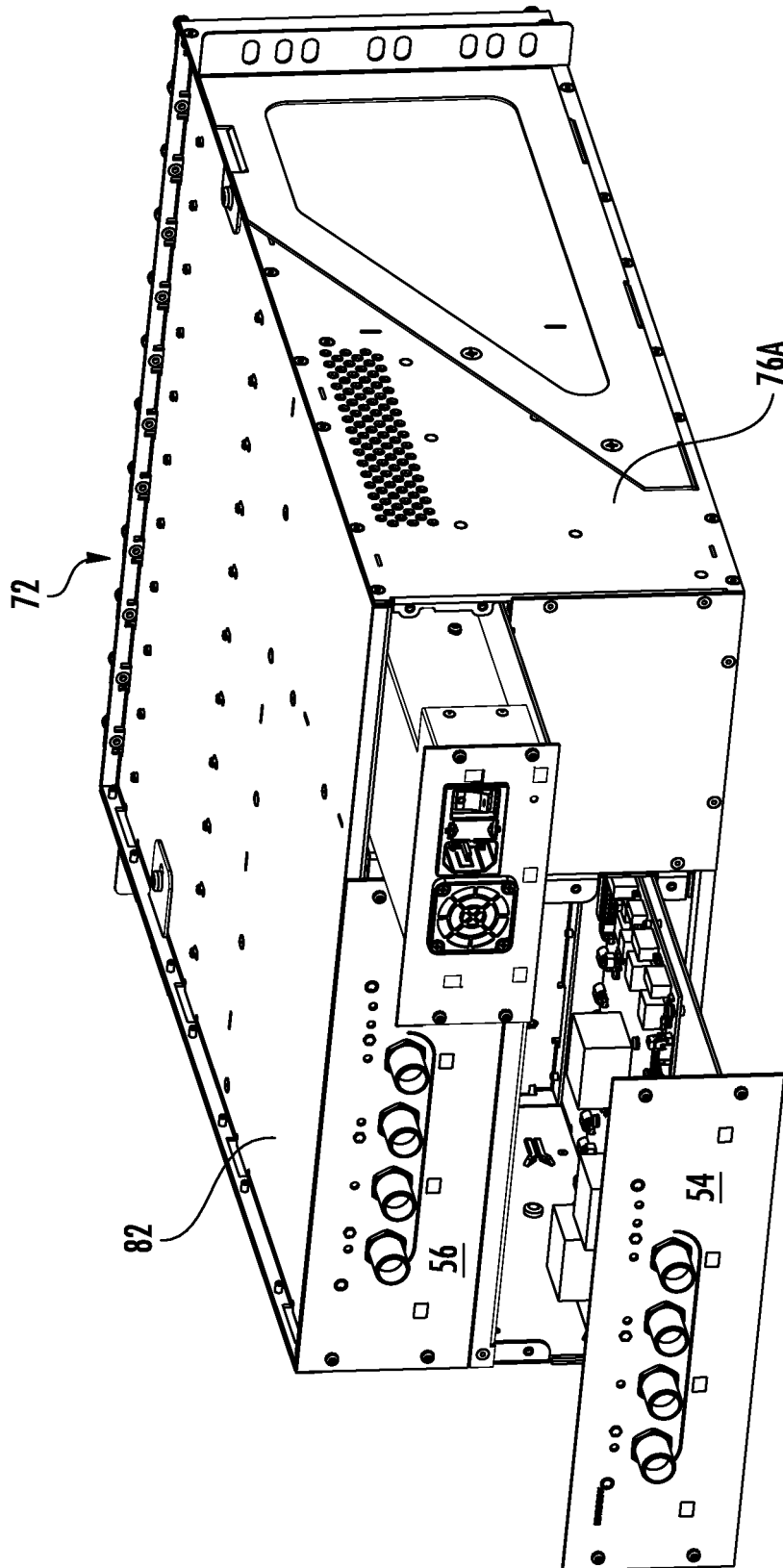
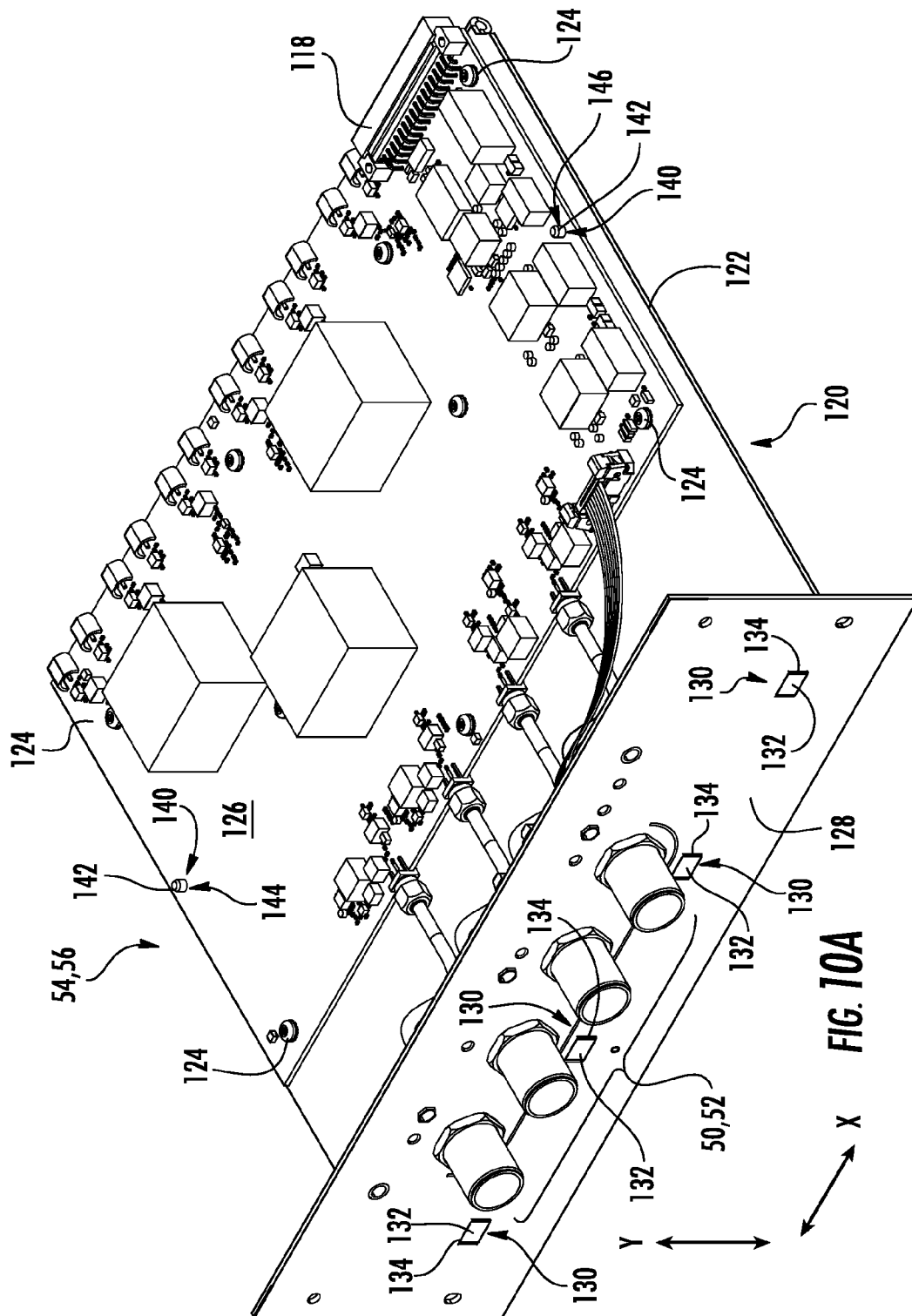
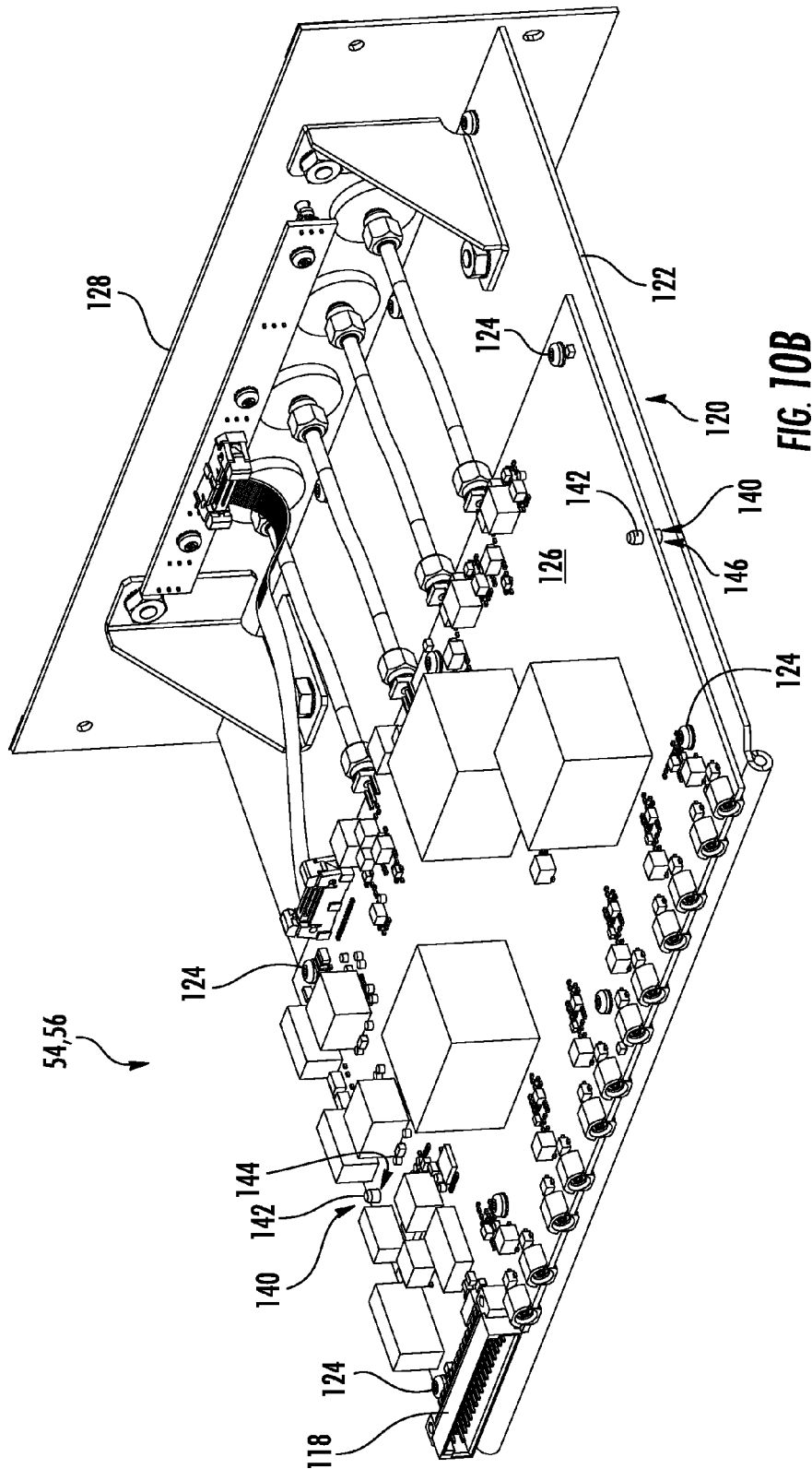
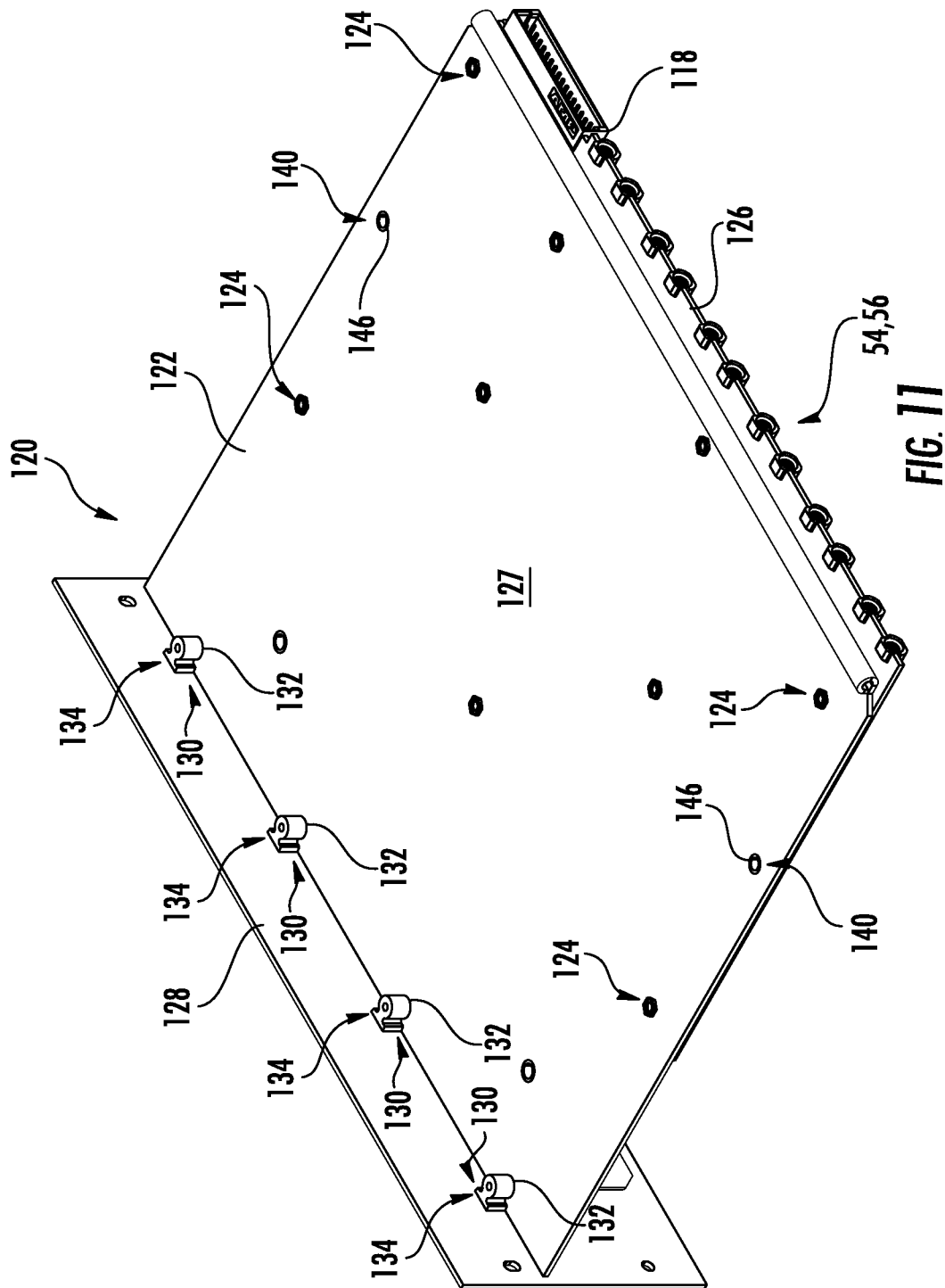
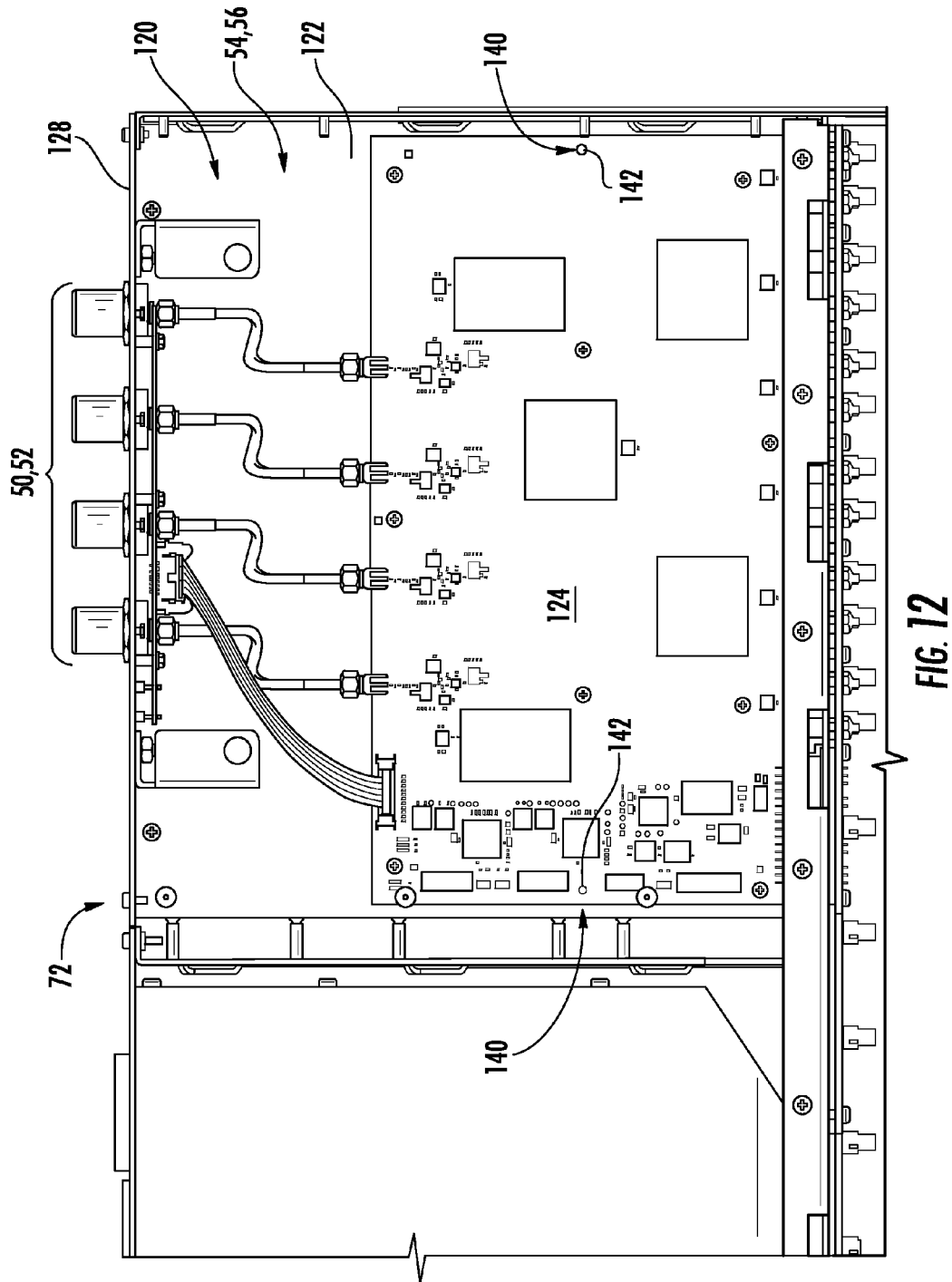


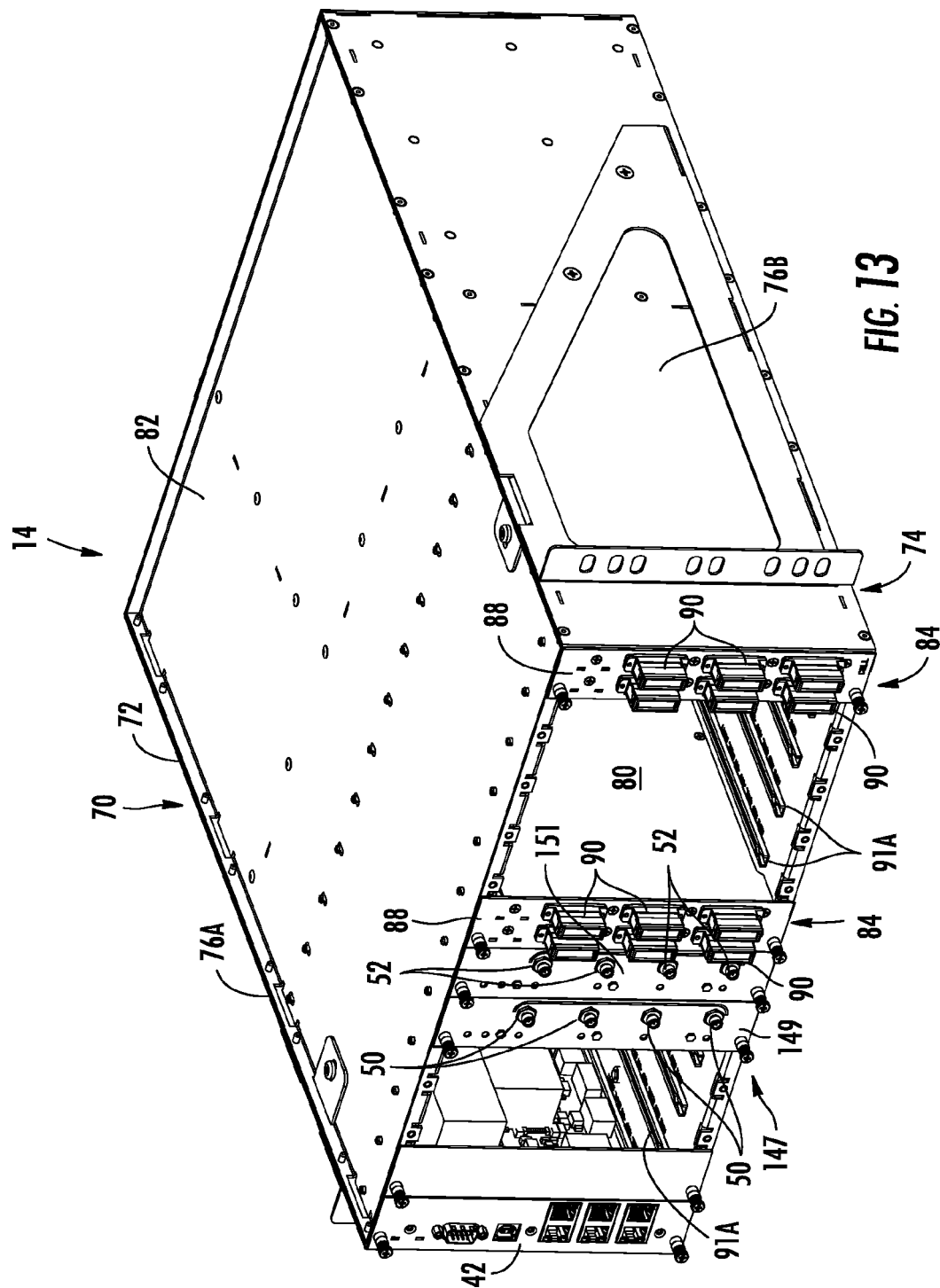
FIG. 9

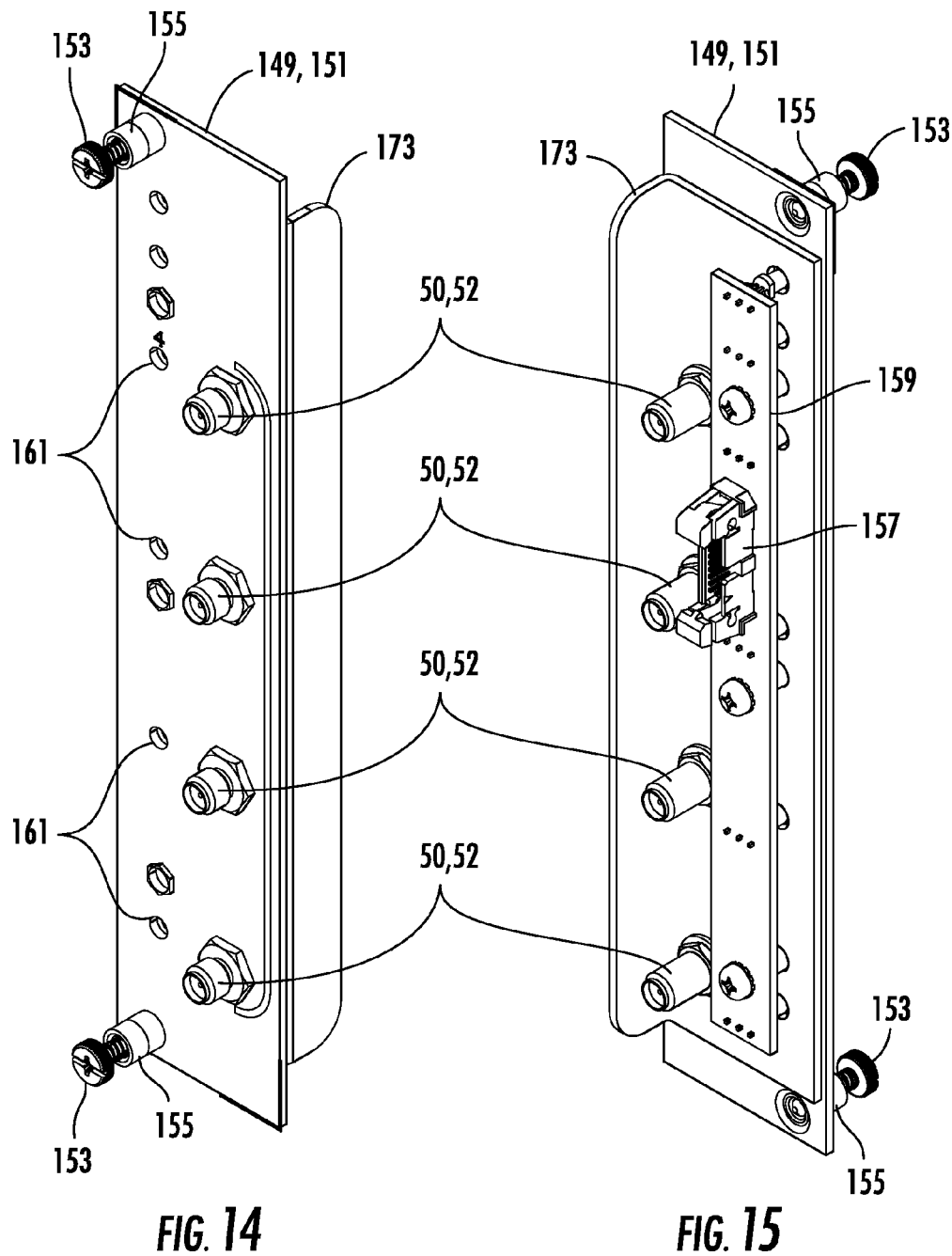


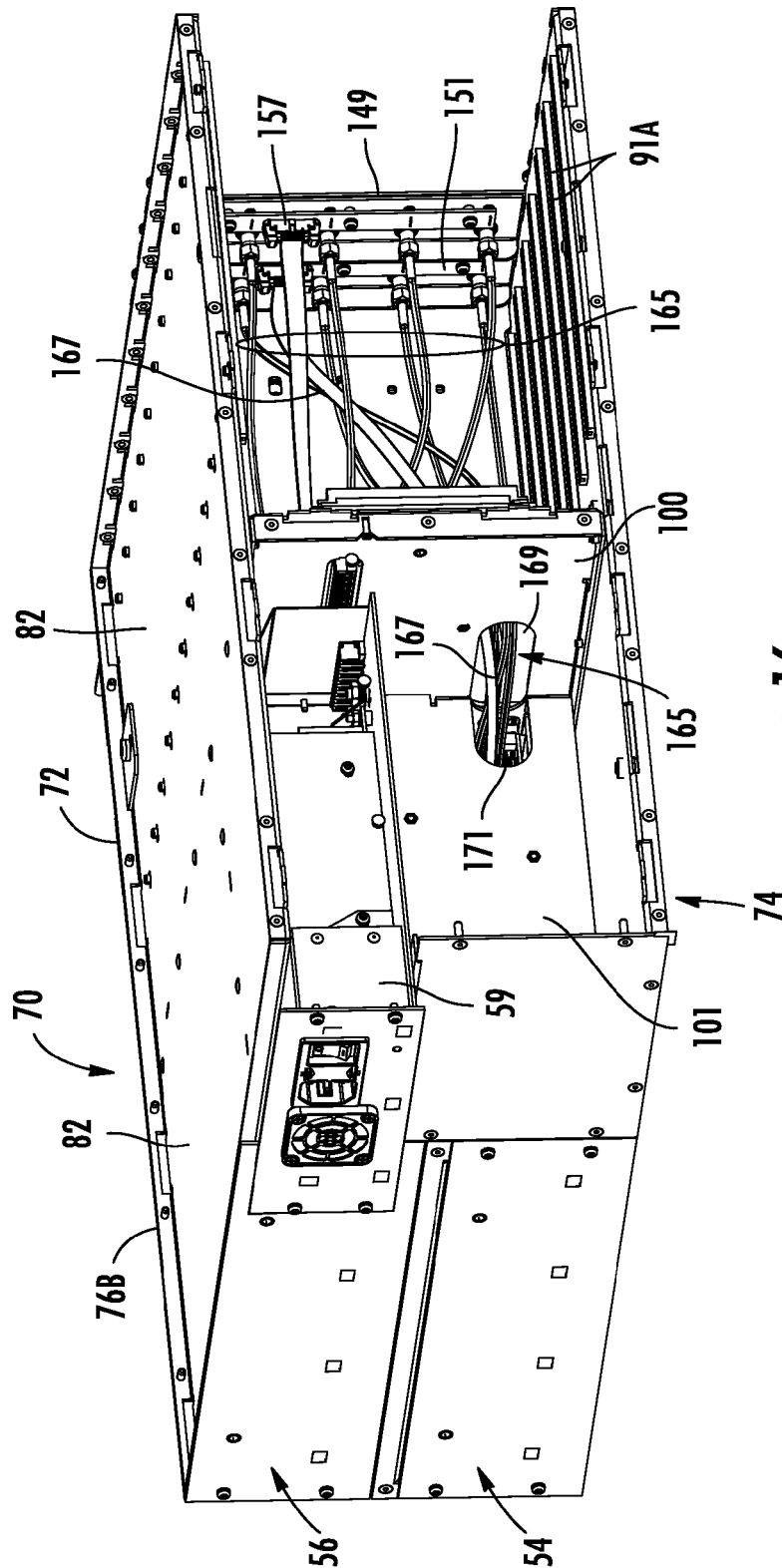












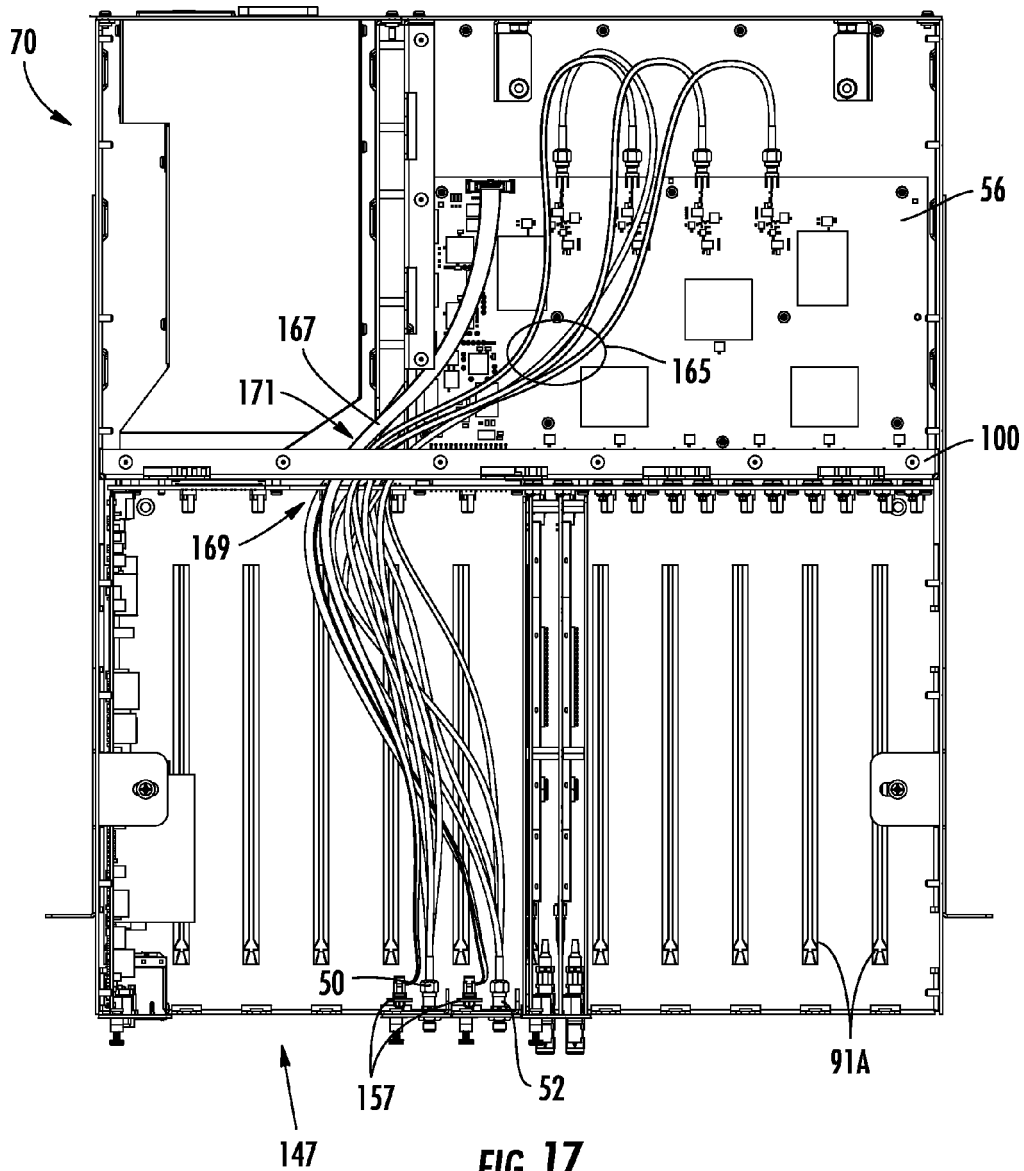


FIG. 17

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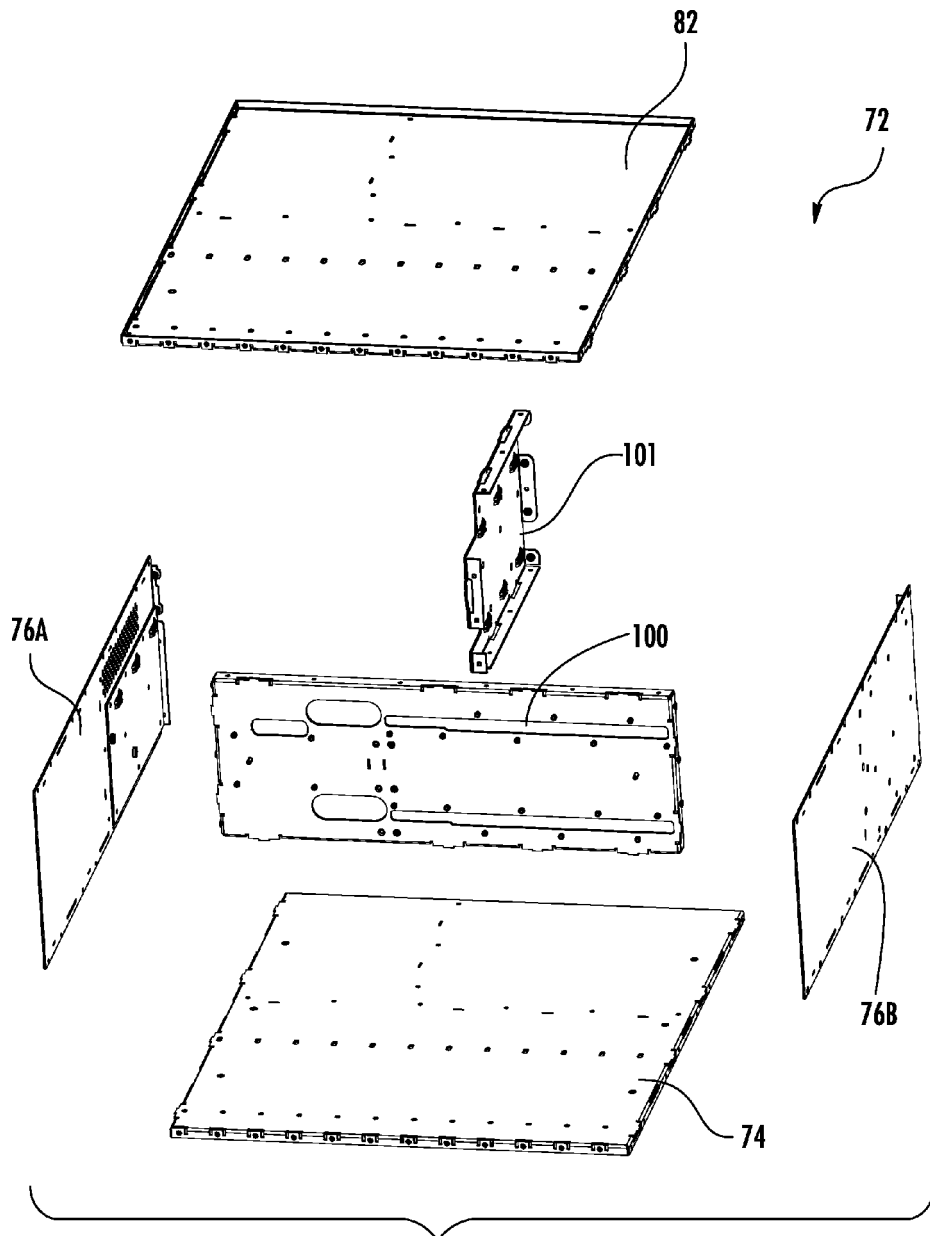


FIG. 18

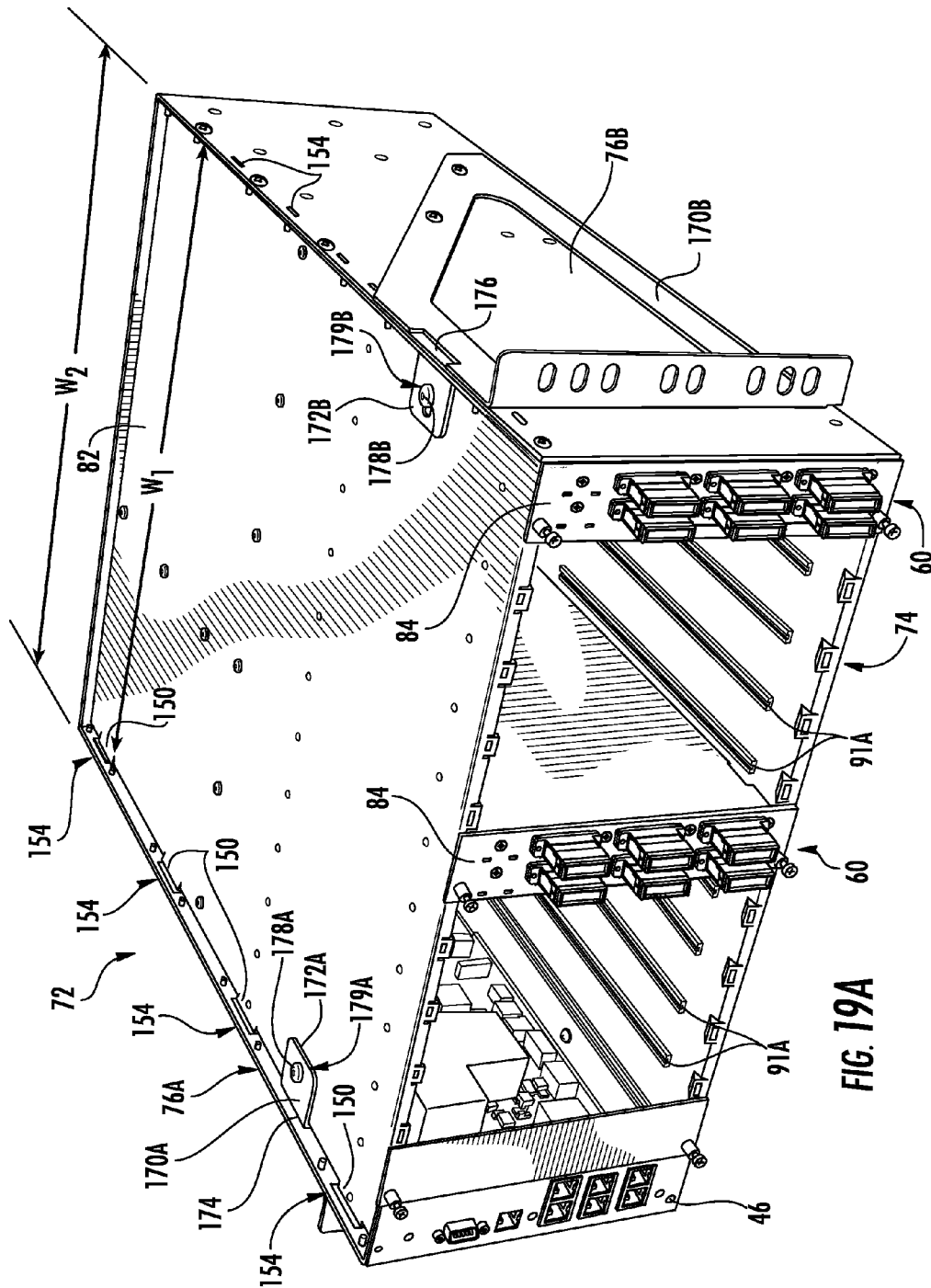


FIG. 19A

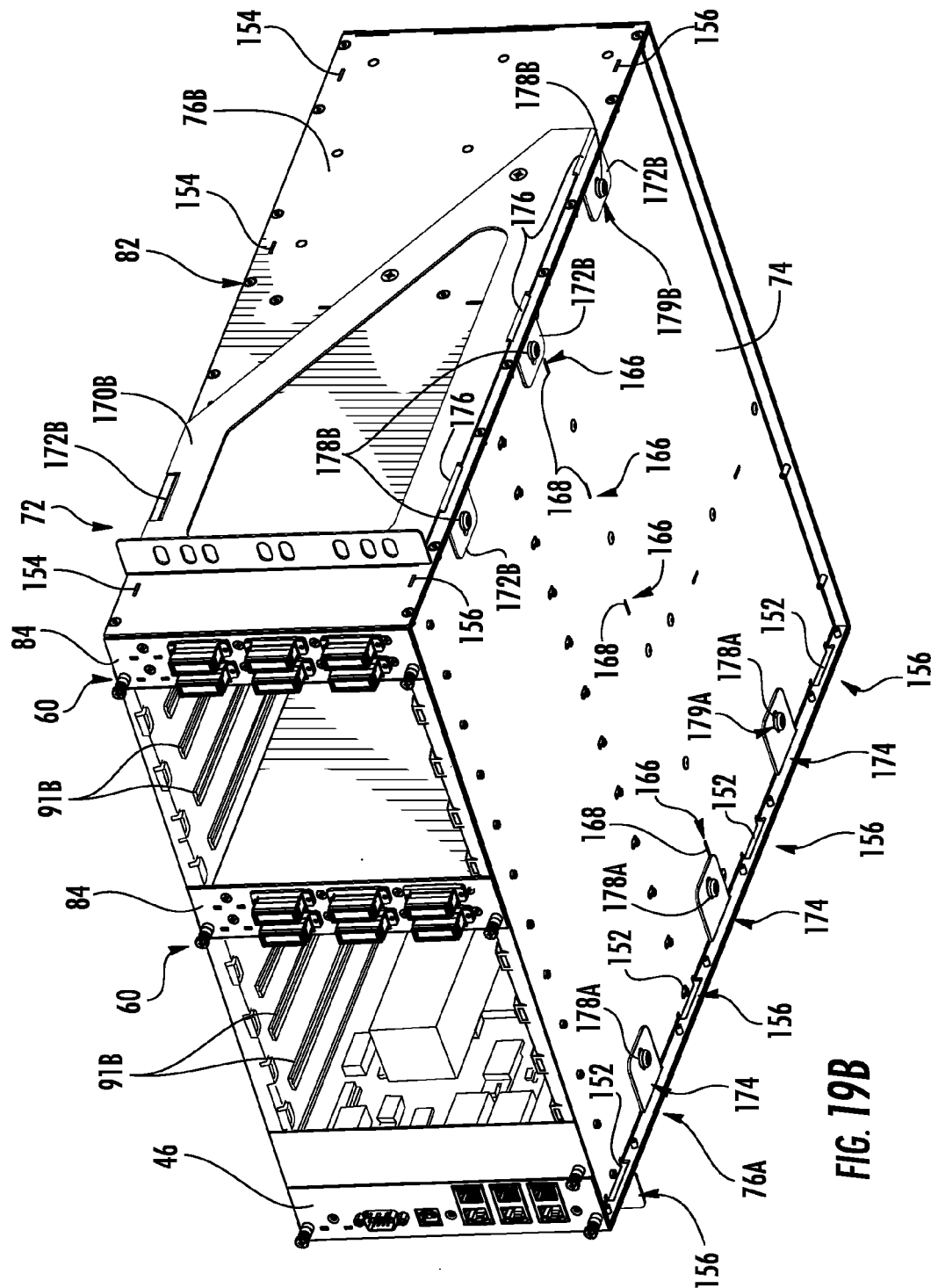


FIG. 19B

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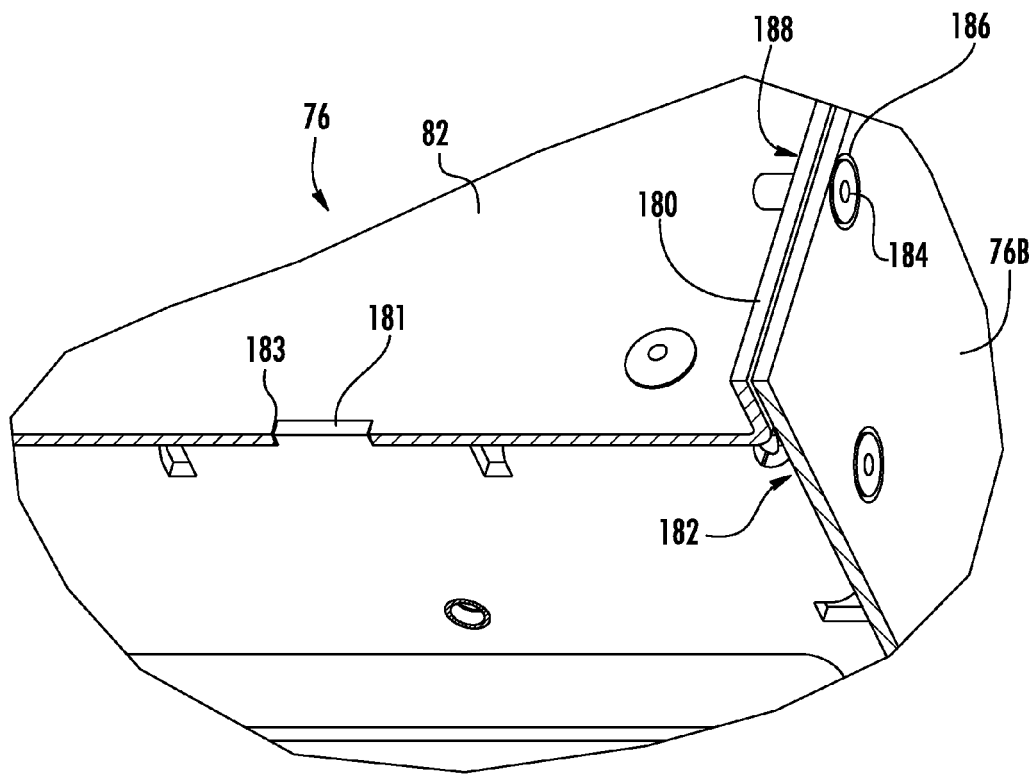
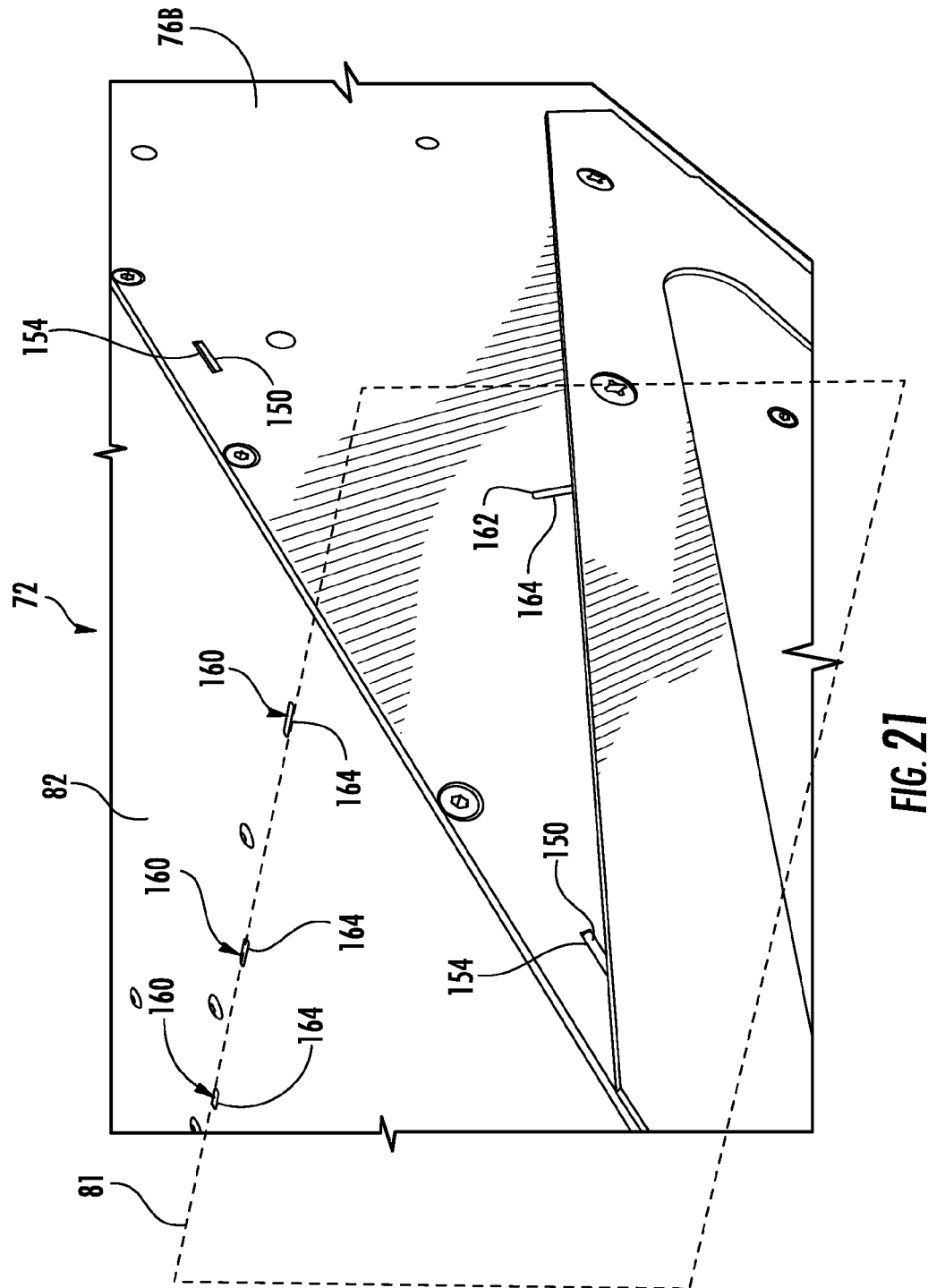
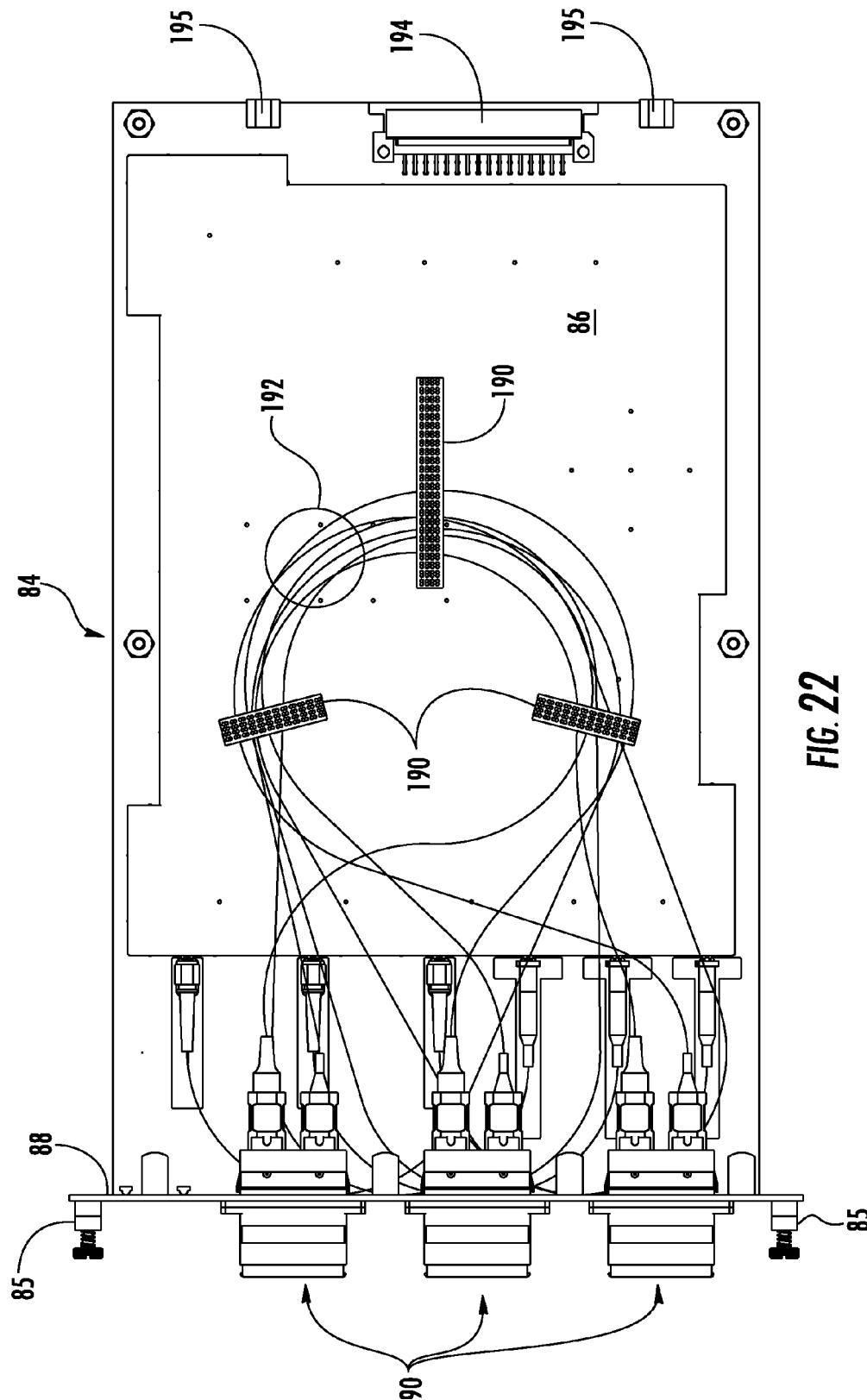
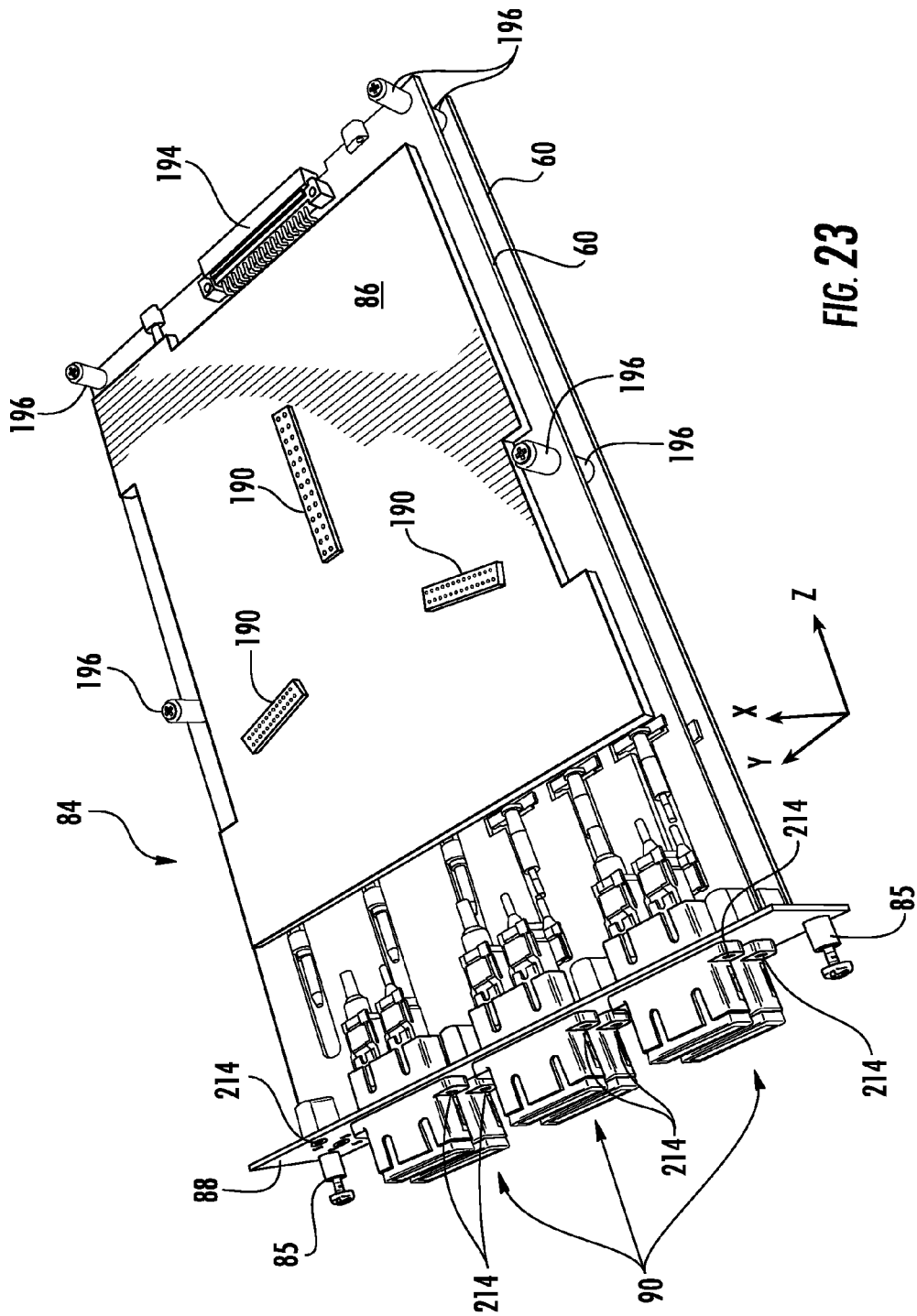
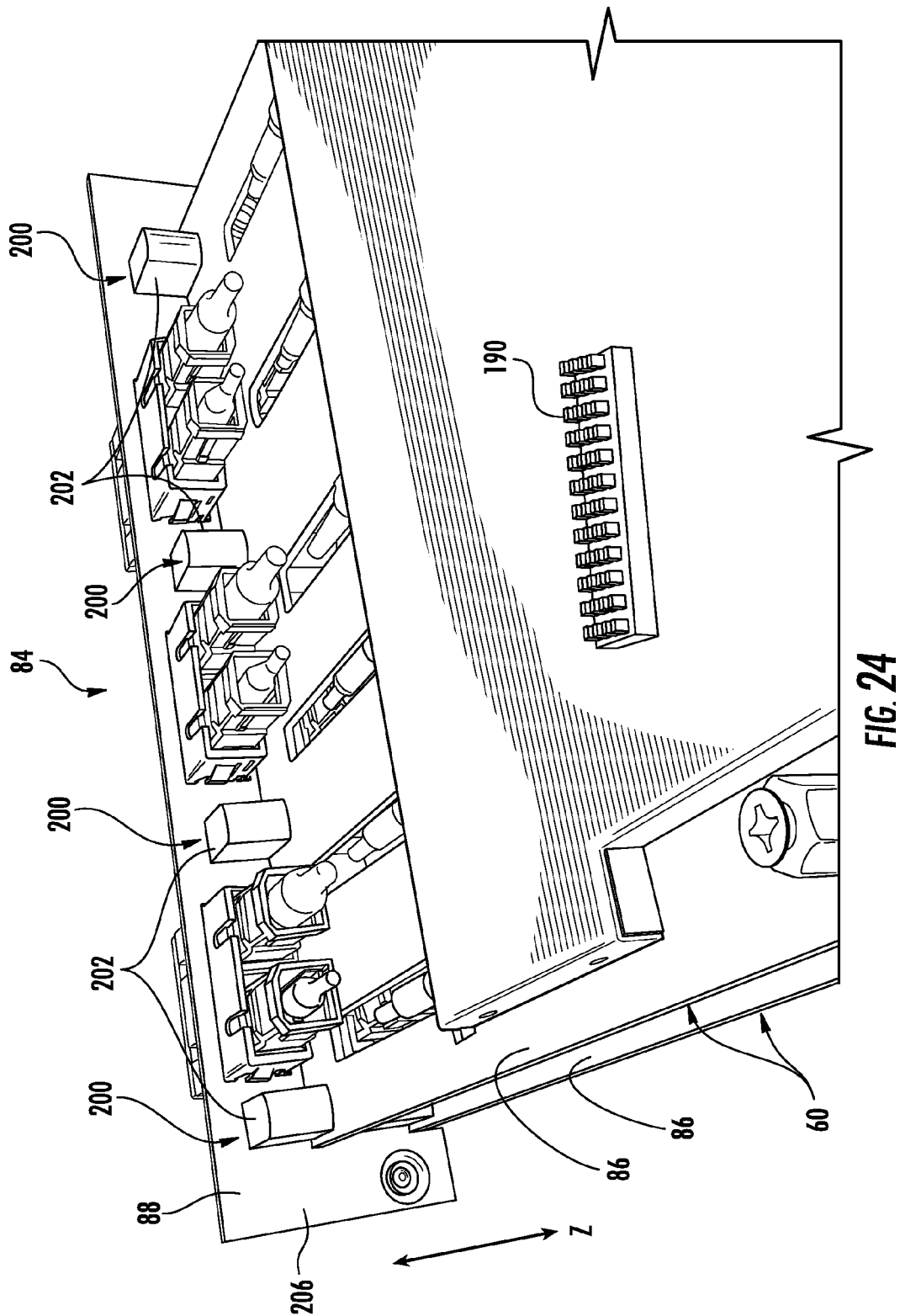


FIG. 20









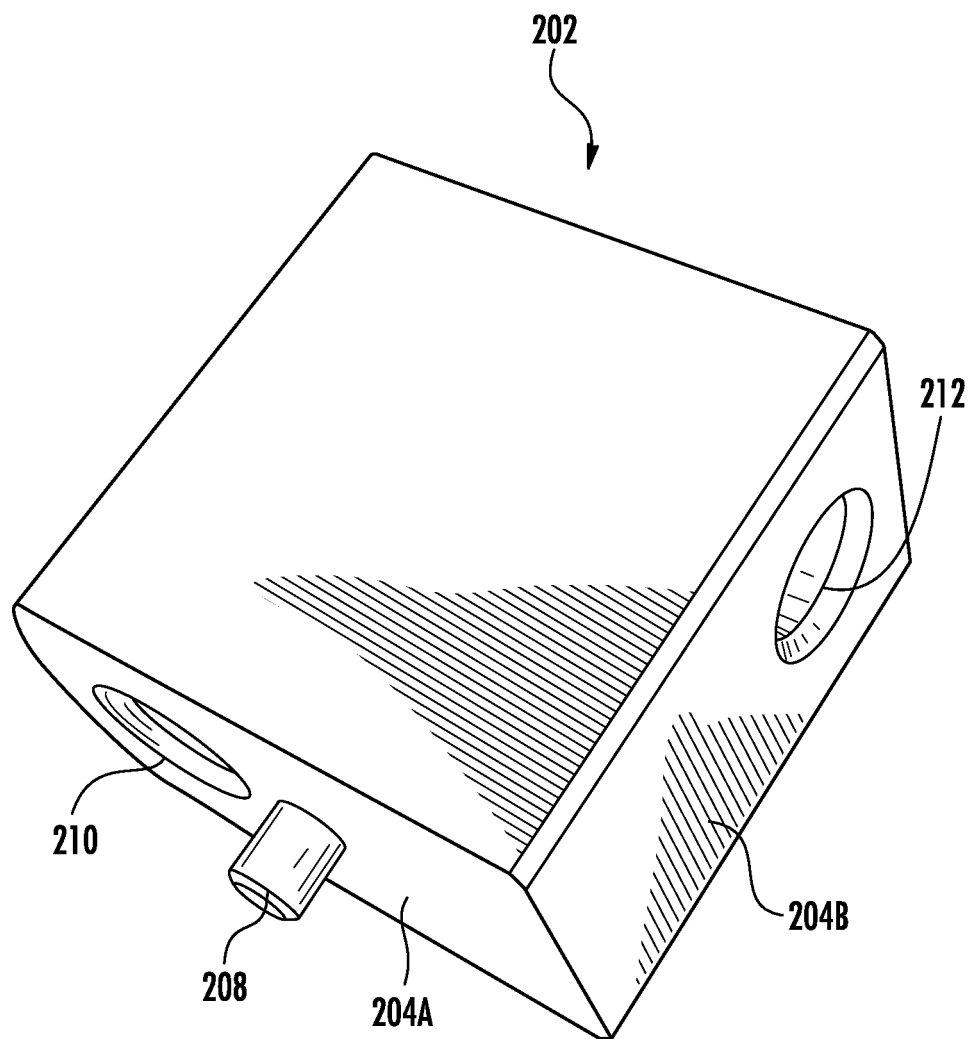
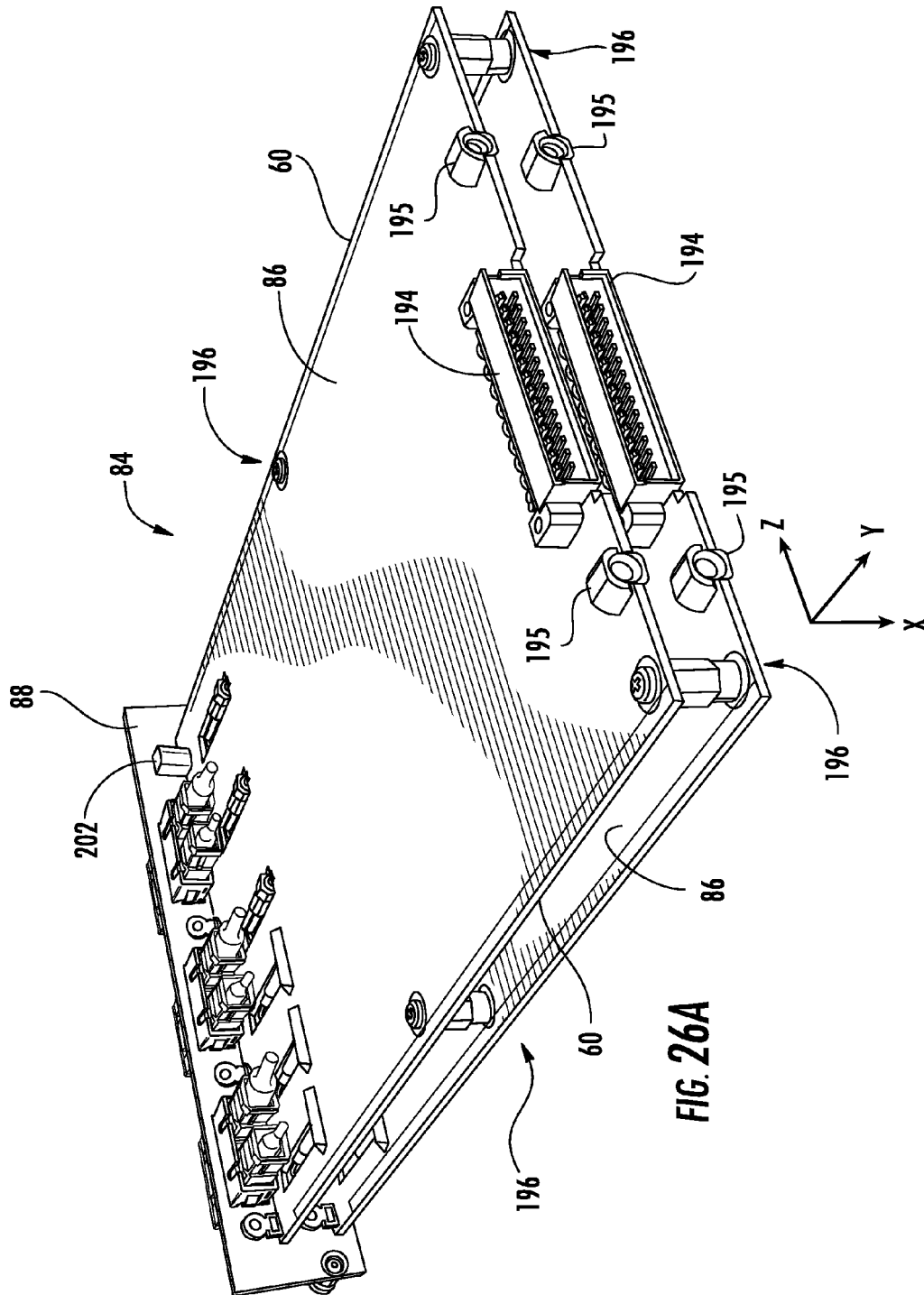
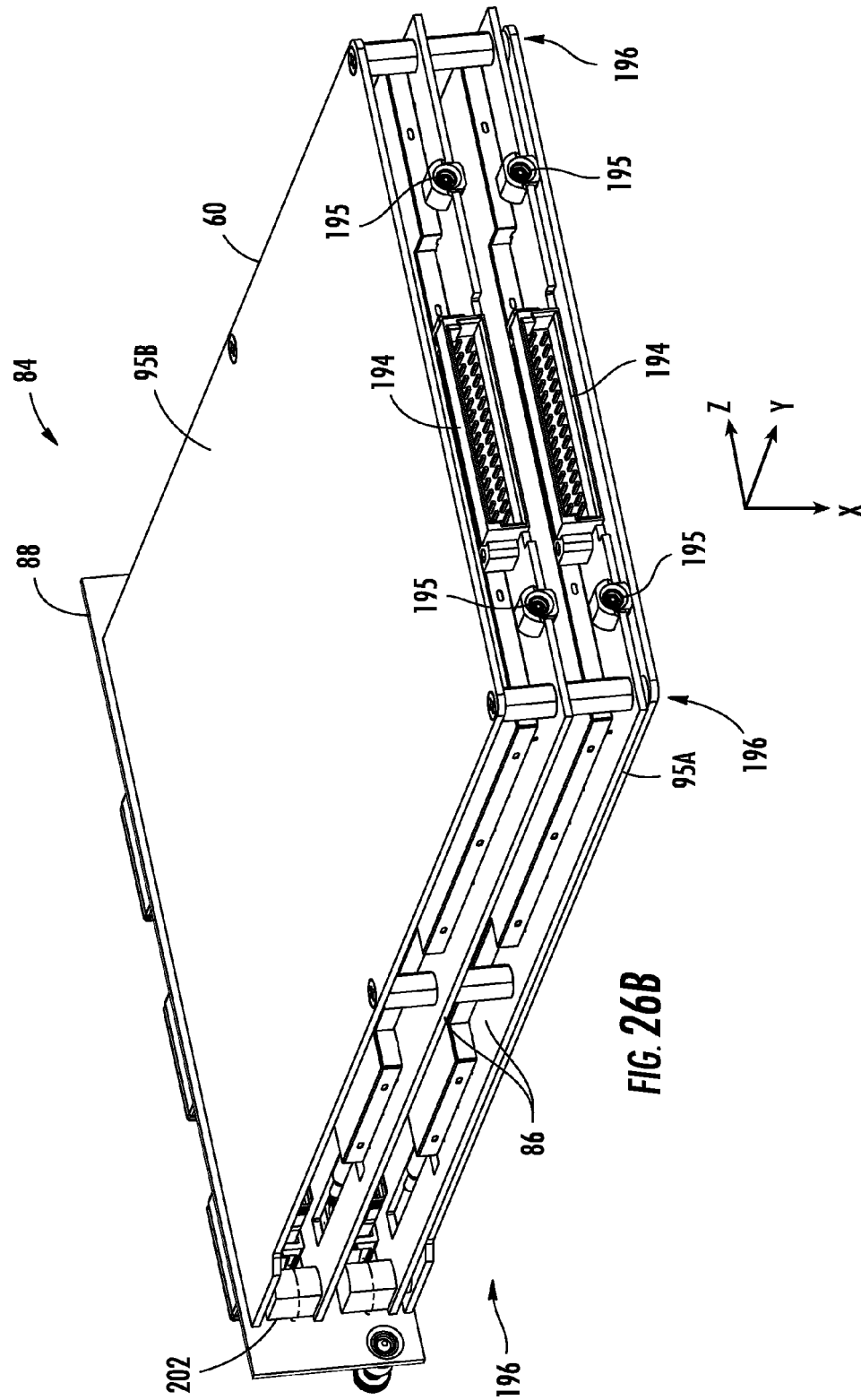
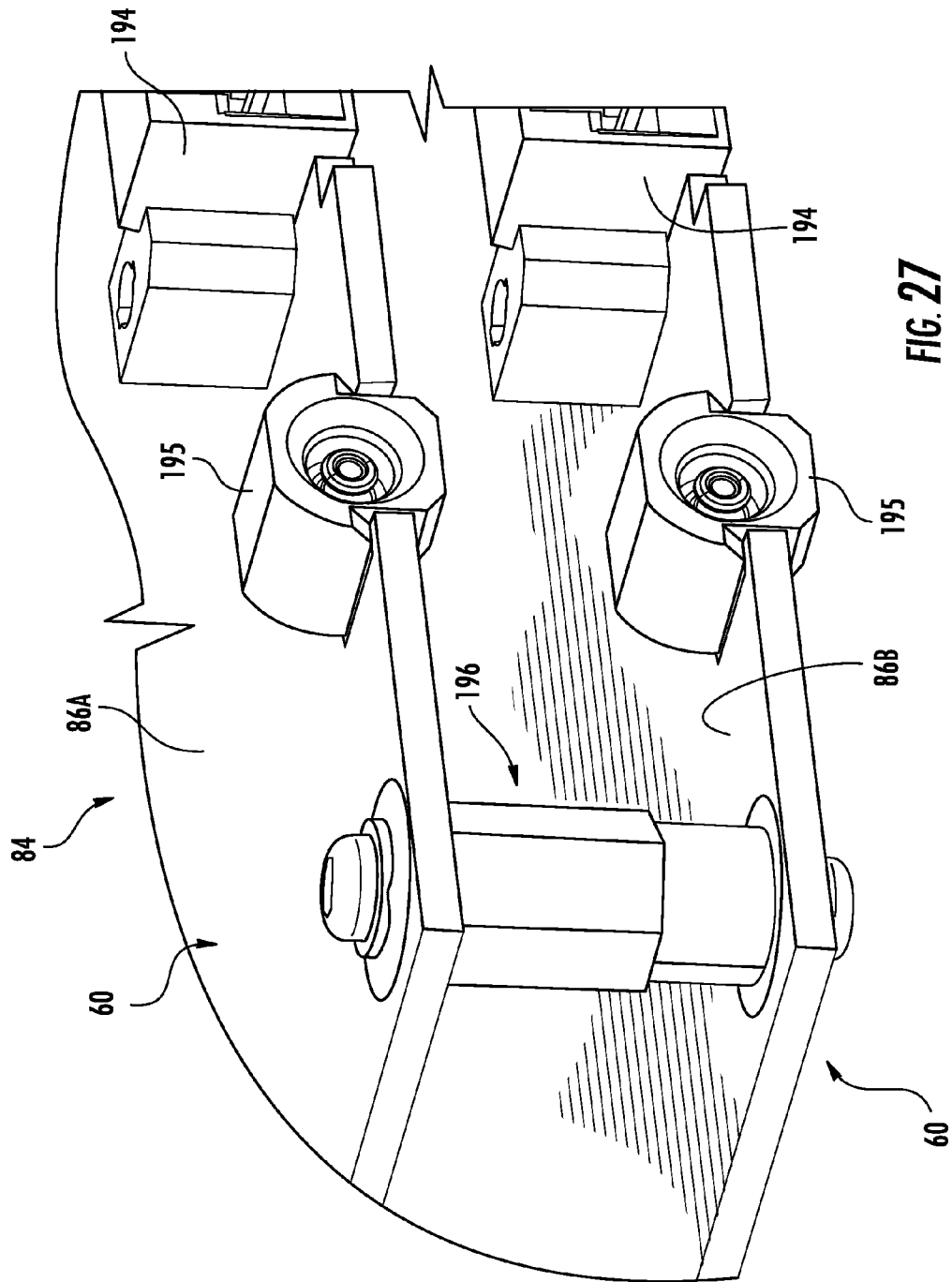


FIG. 25







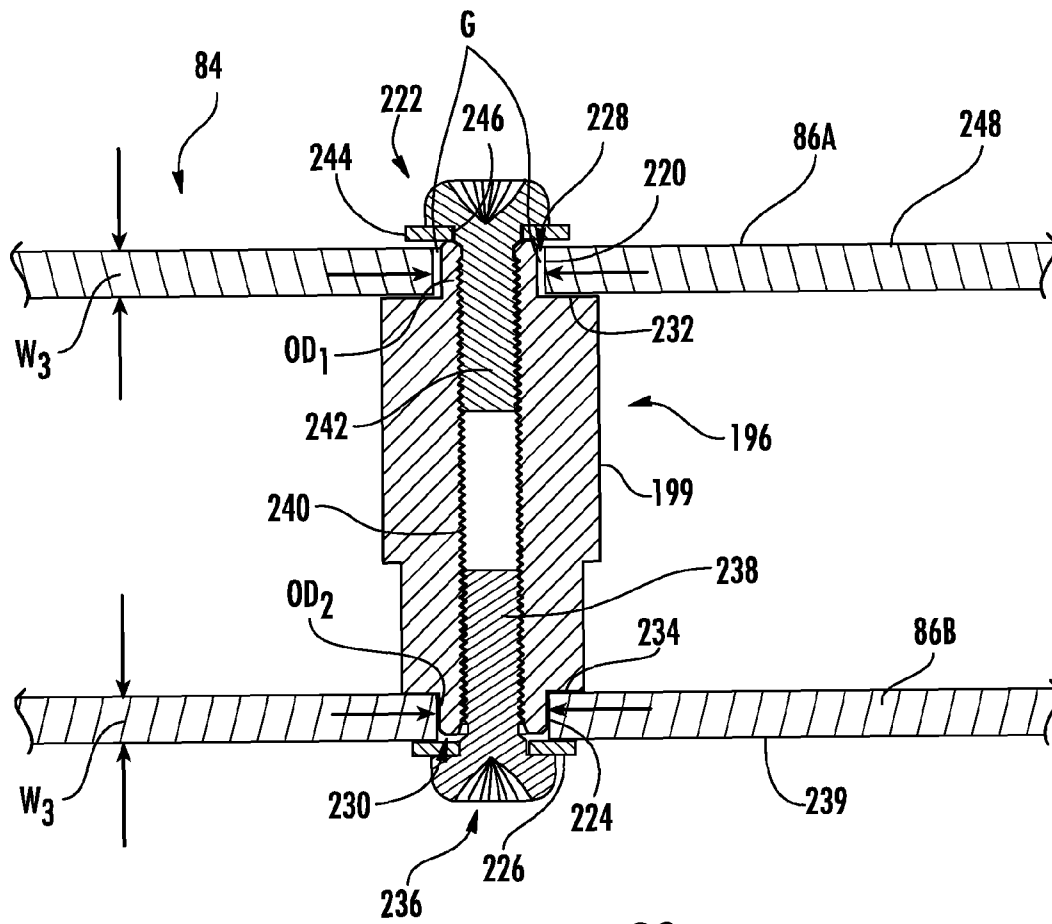
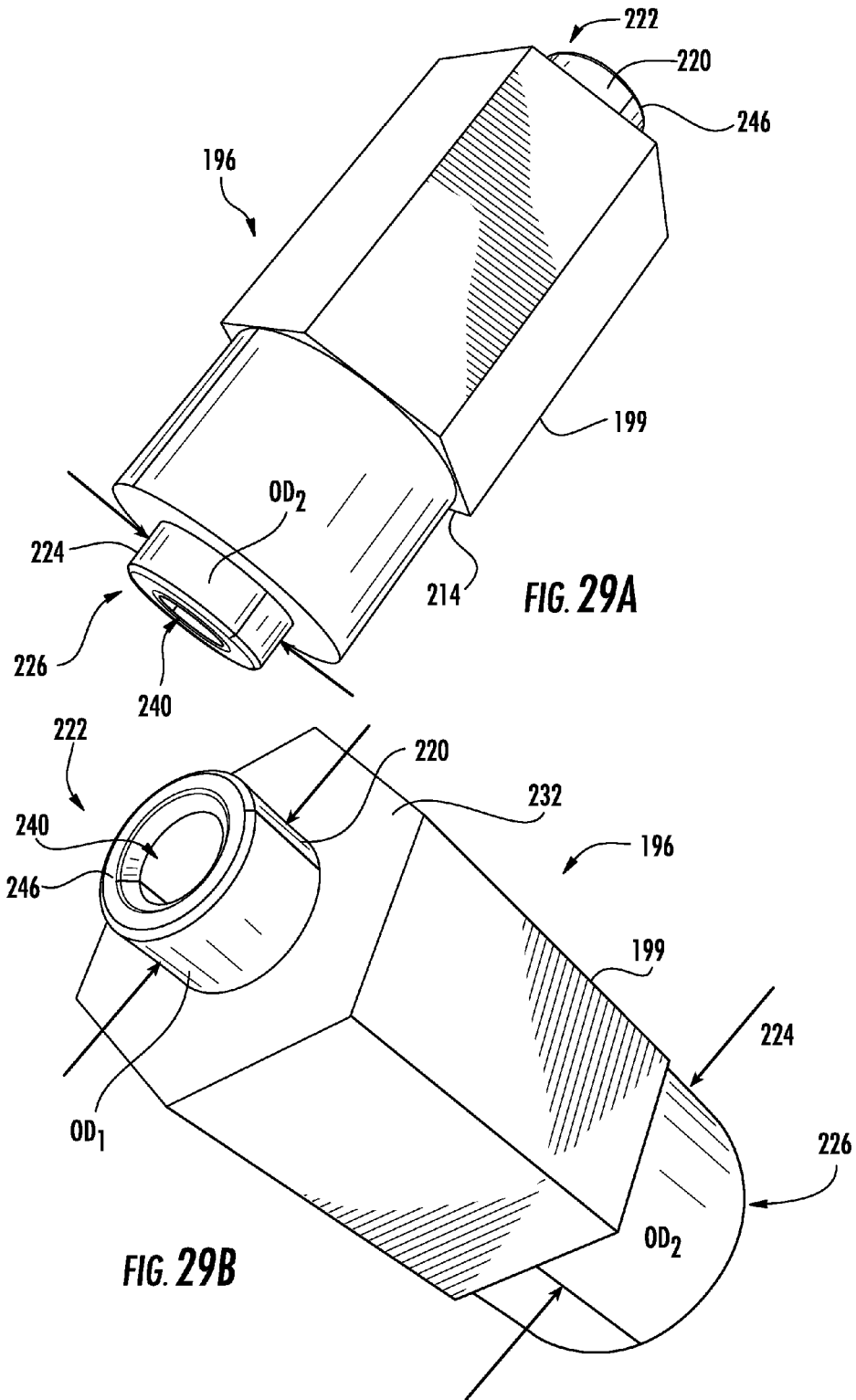
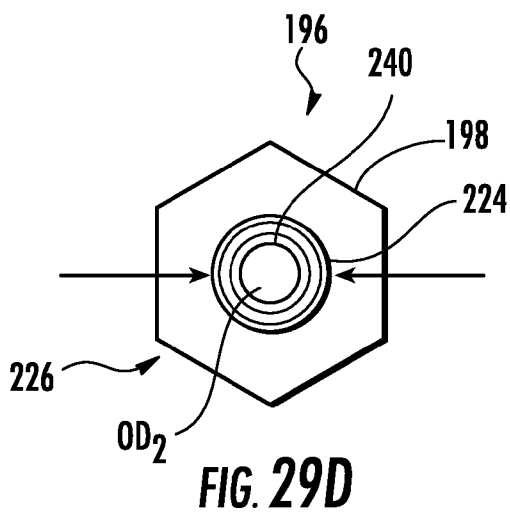
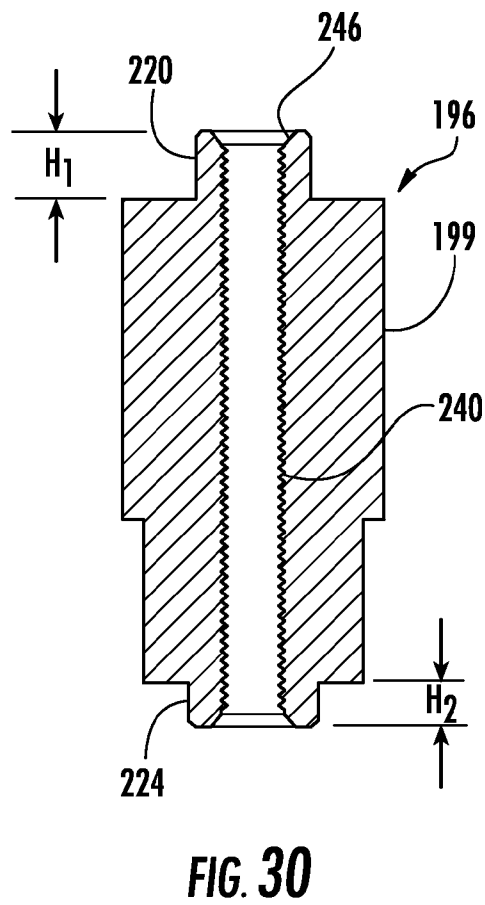
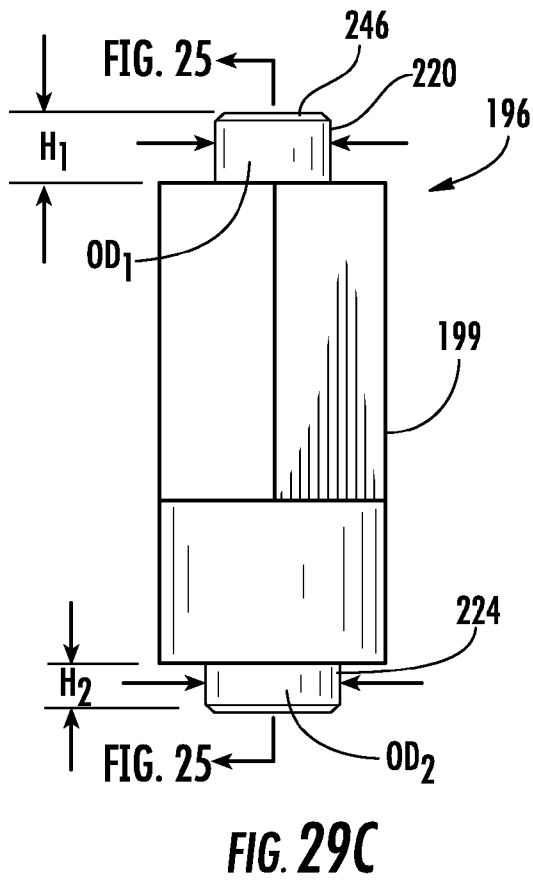


FIG. 28





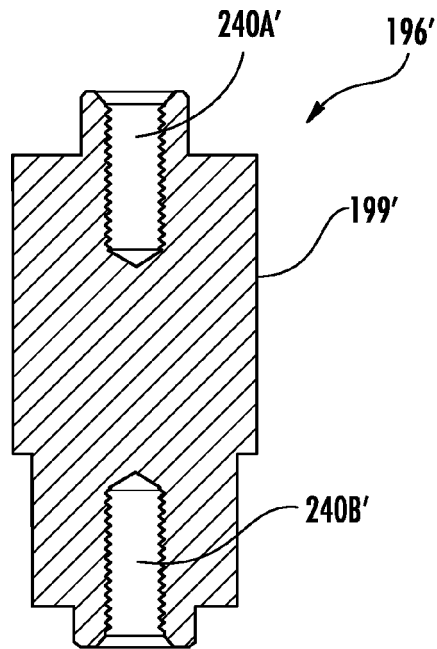


FIG. 31

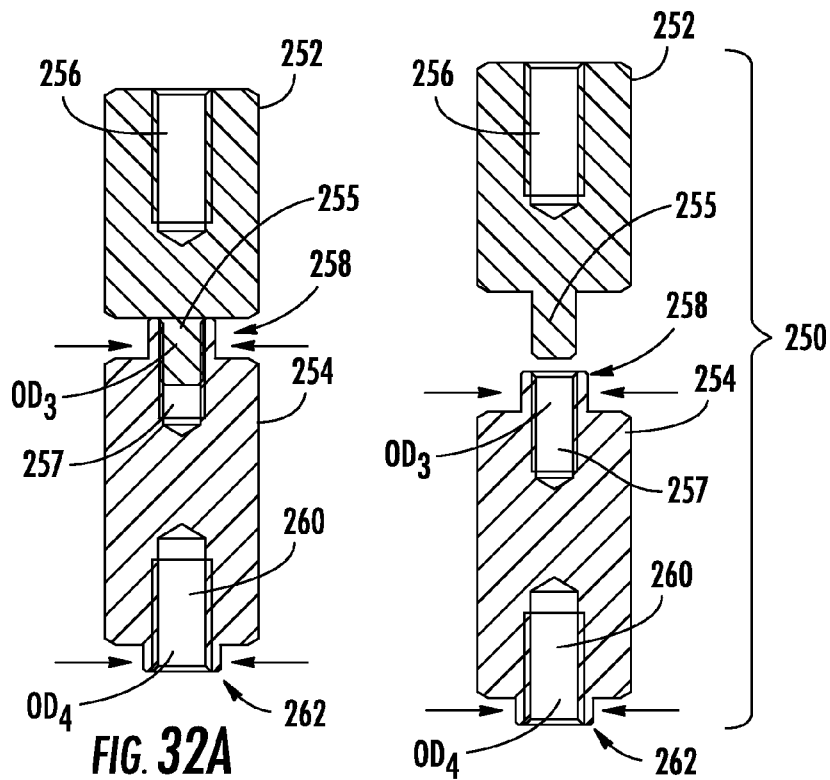


FIG. 32A

FIG. 32B

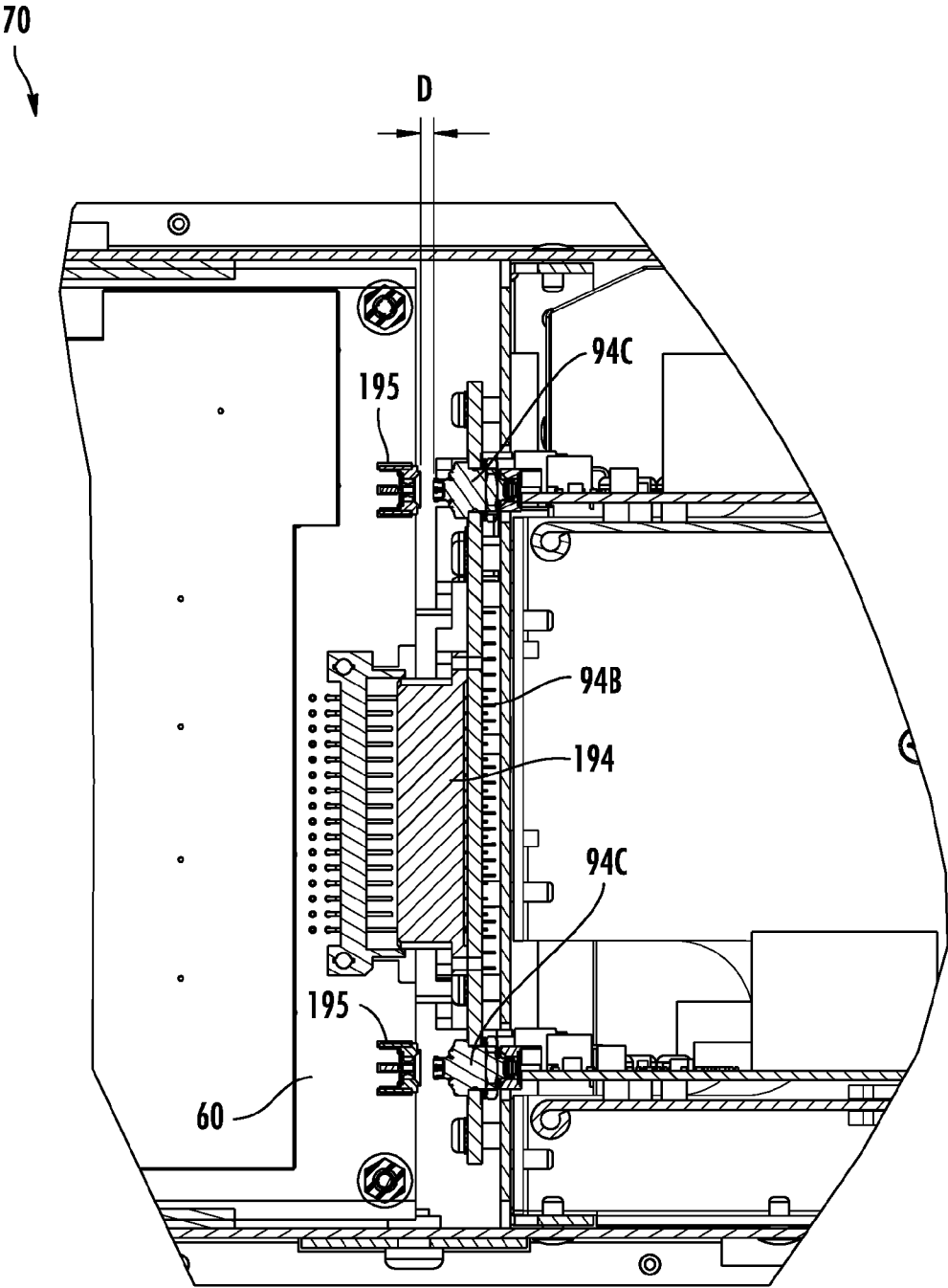
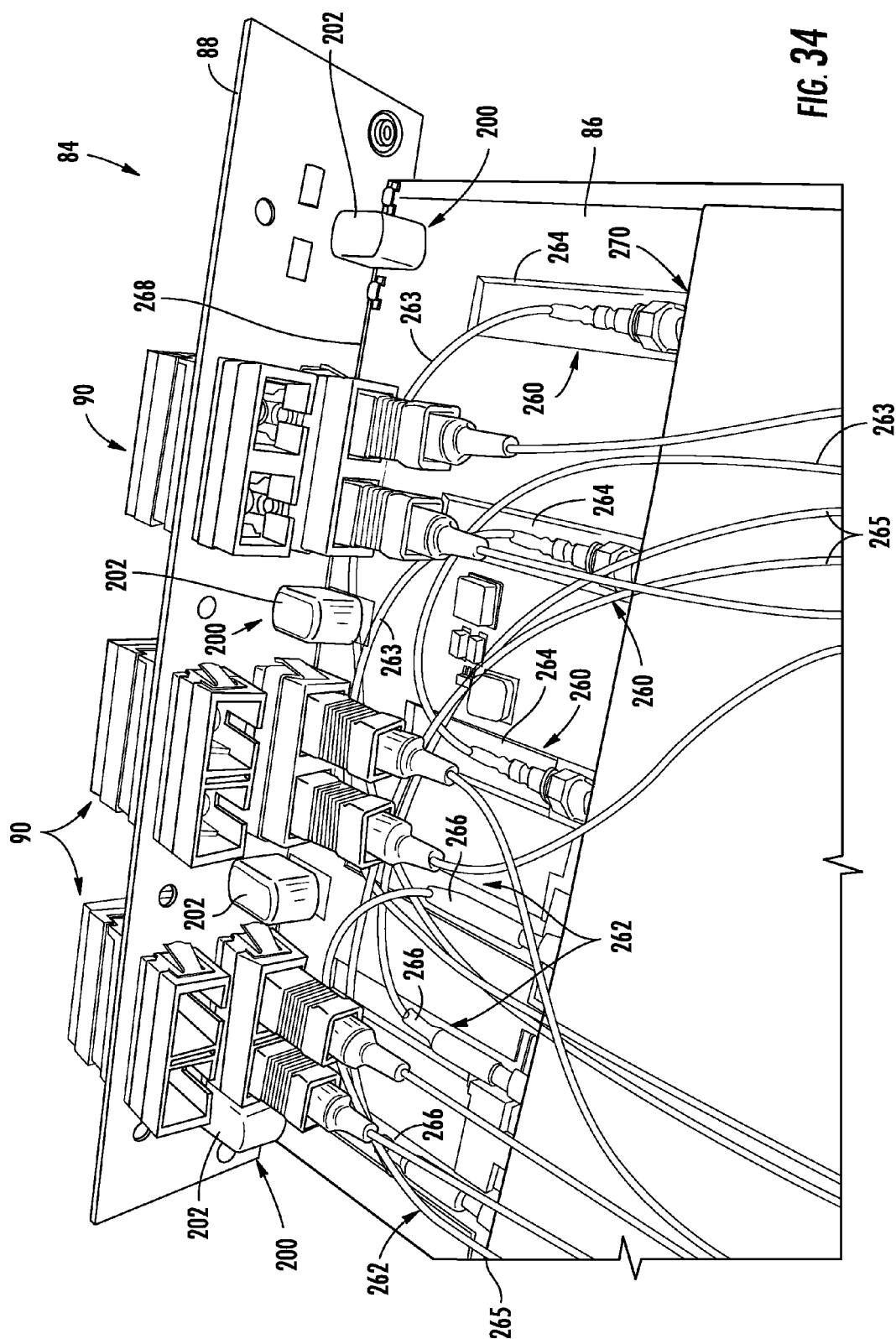


FIG. 33



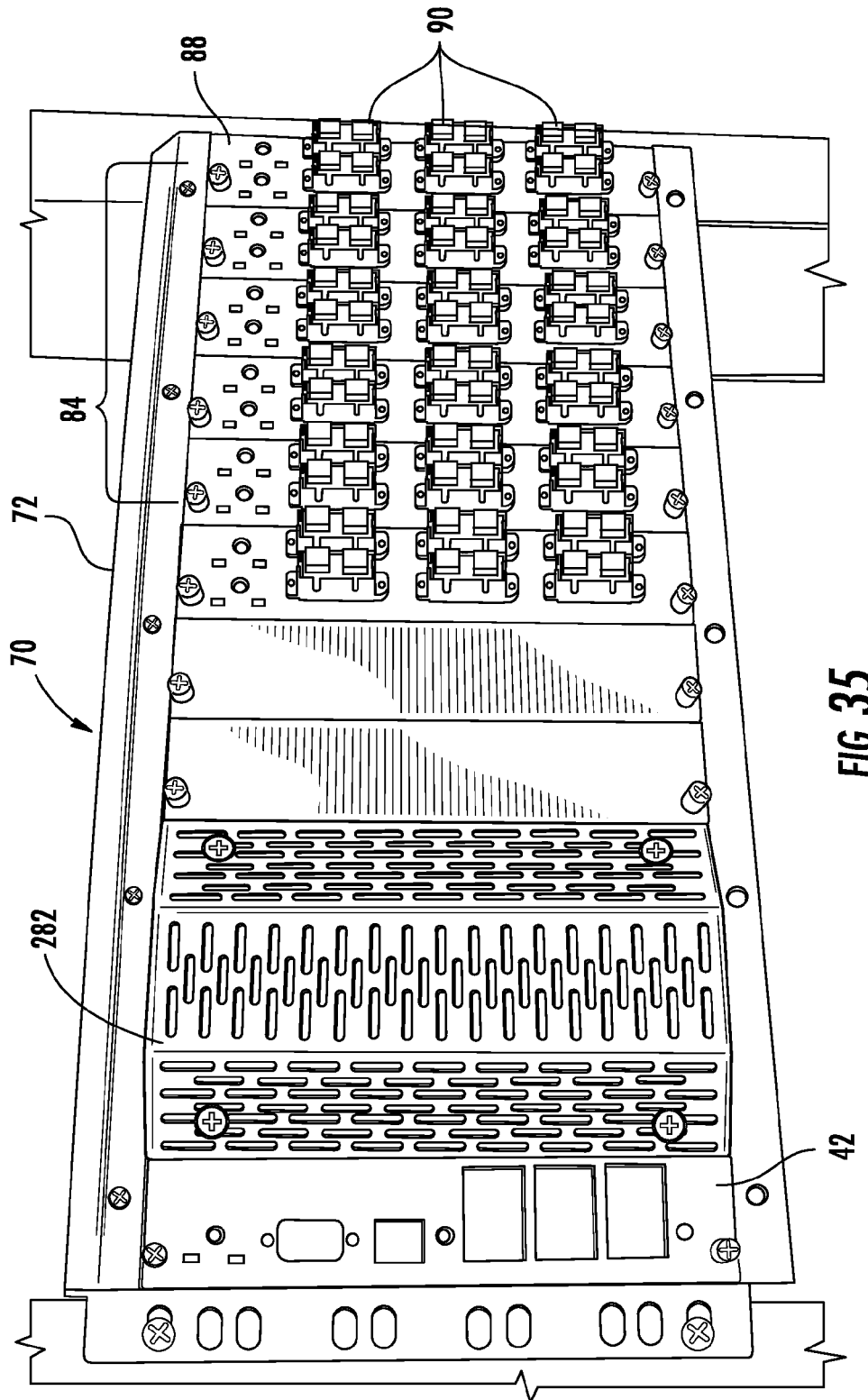
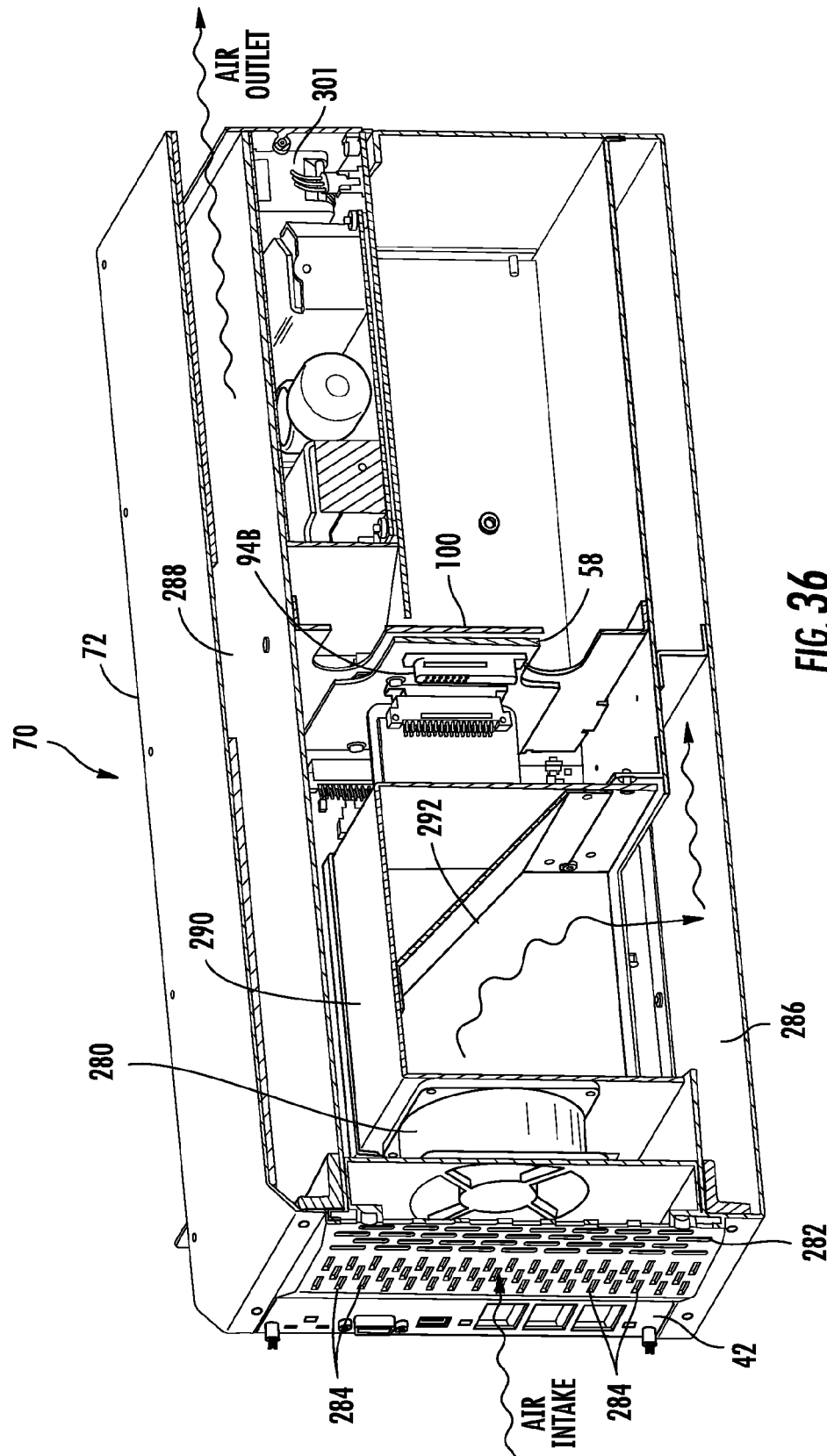


FIG. 35



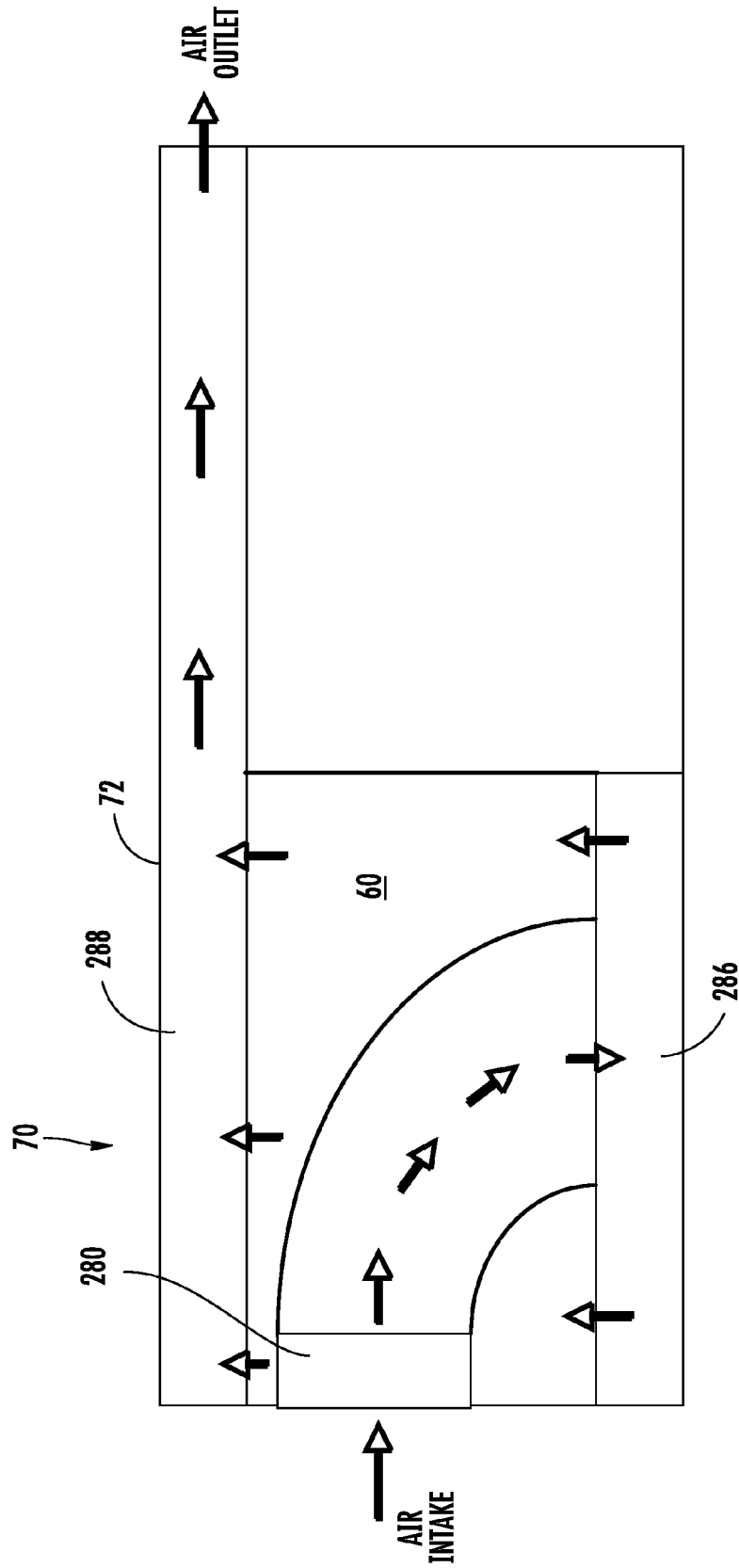
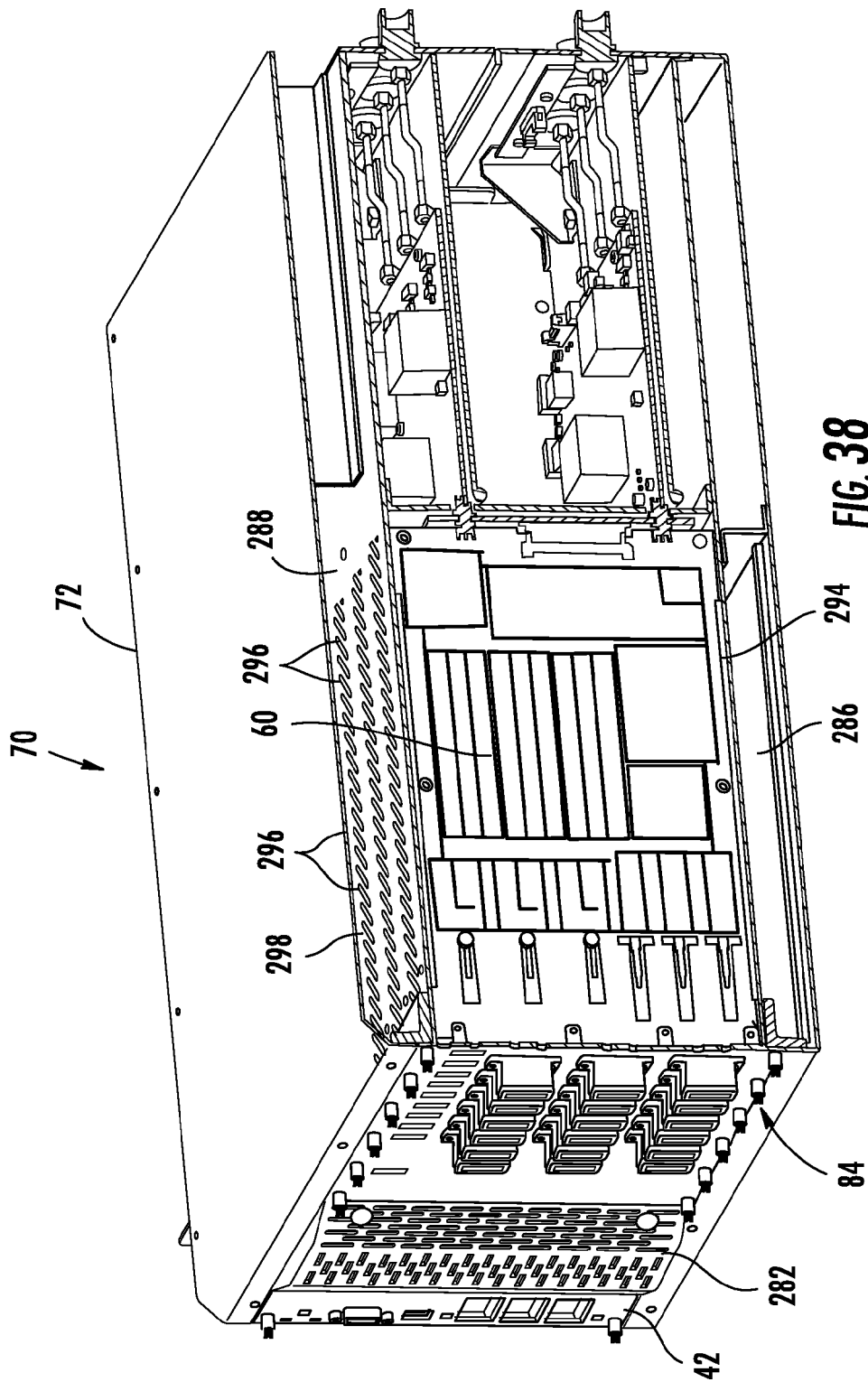
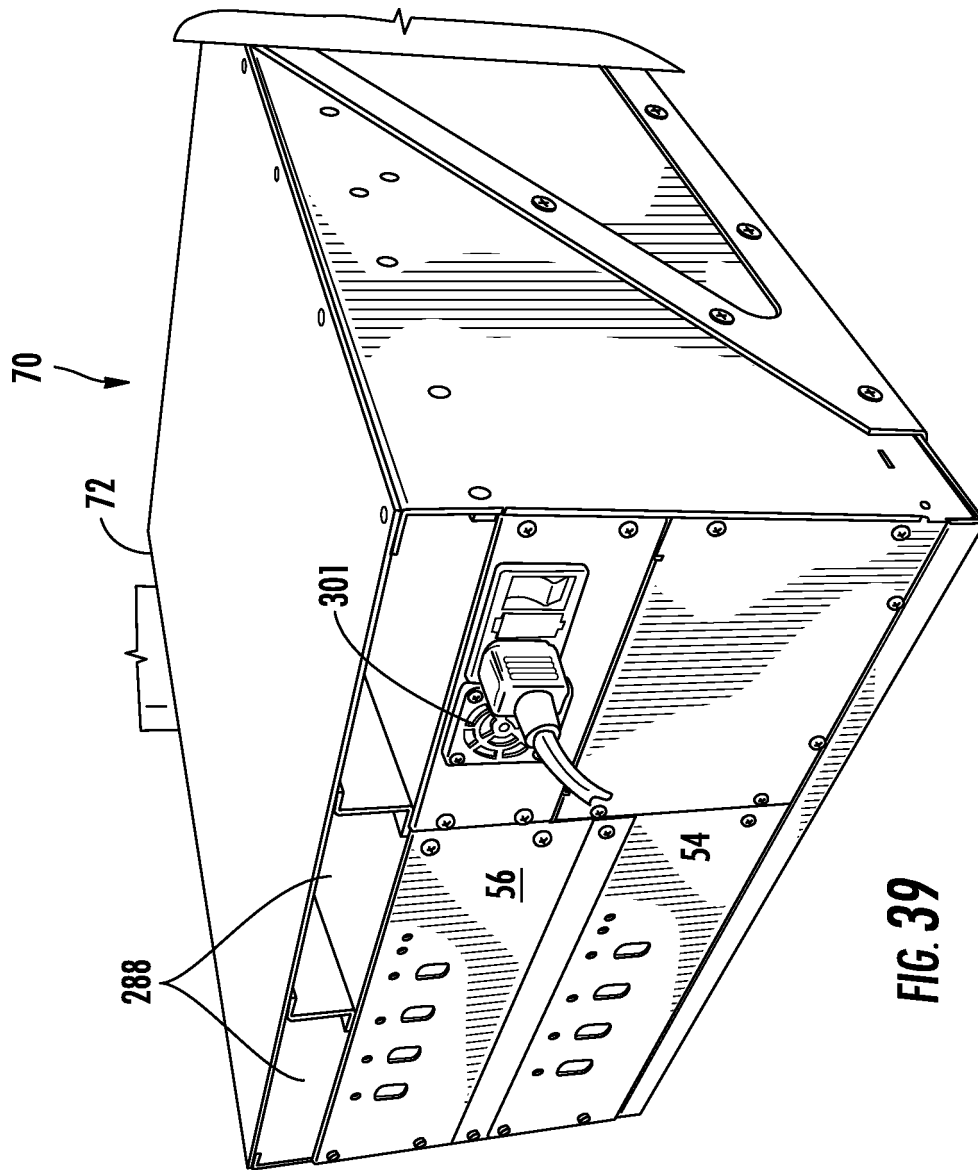
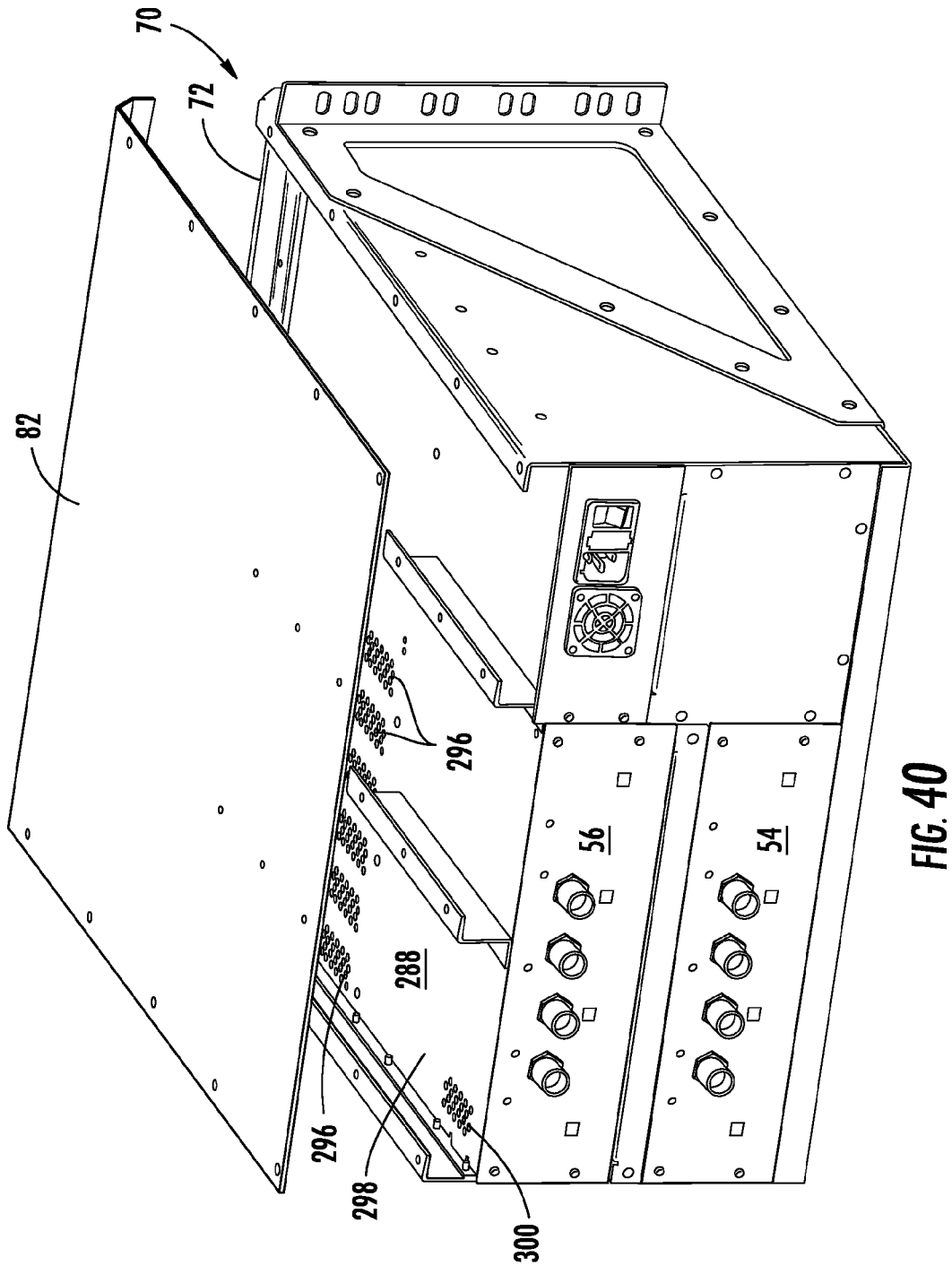


FIG. 37







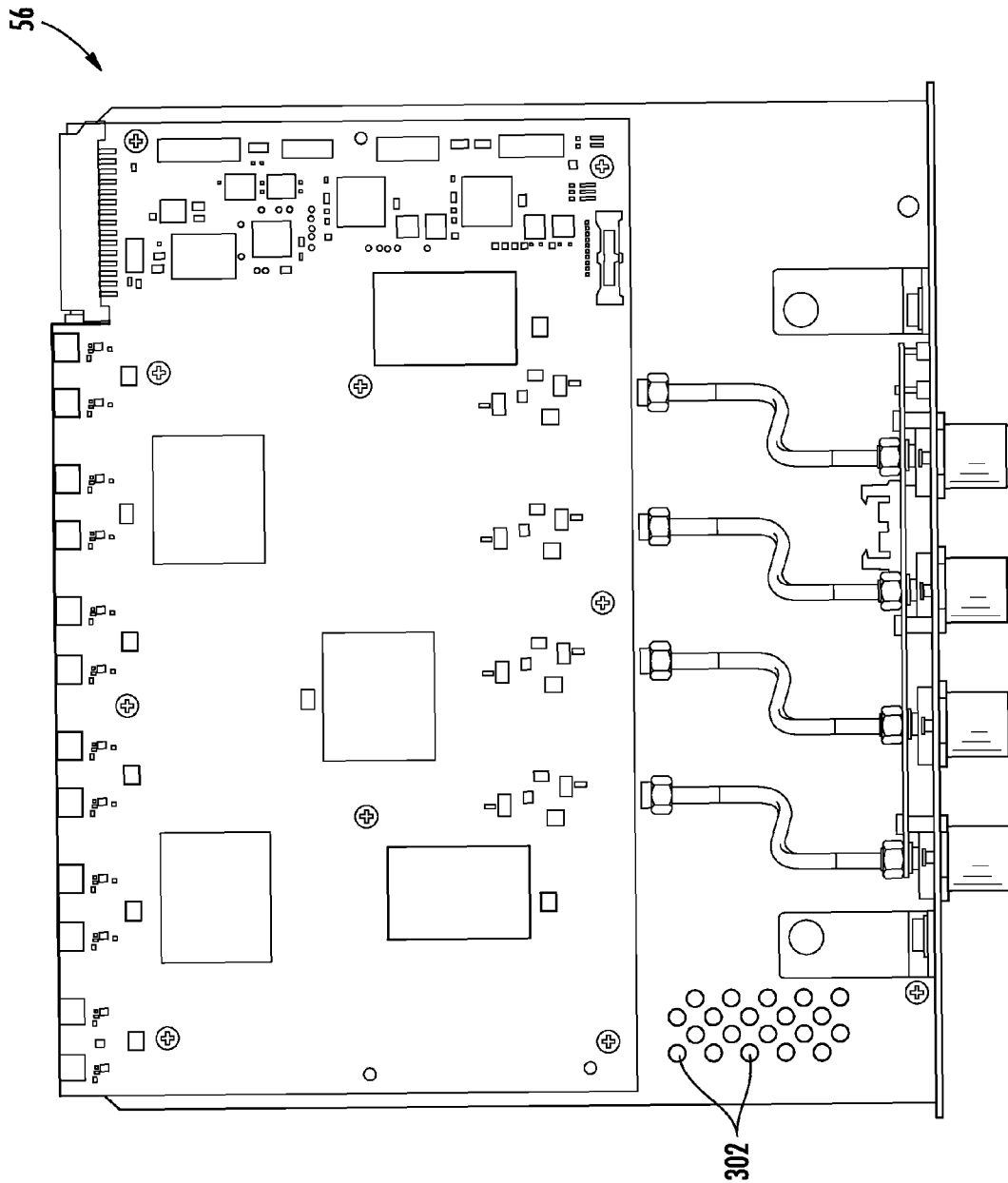


FIG. 41

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COMMUNICATIONS EQUIPMENT HOUSINGS, ASSEMBLIES, AND RELATED ALIGNMENT FEATURES AND METHODS

RELATED APPLICATIONS

This application is related to U.S. Provisional Patent Application Ser. No. 61/301,495 filed Feb. 4, 2010 entitled "Modular Distributed Antenna System Equipment Housings, Assemblies, And Related Alignment Feature," which is incorporated herein by reference in its entirety.

This application is also related to U.S. Provisional Patent Application Ser. No. 61/301,488 filed Feb. 4, 2010 entitled "Modular Distributed Antenna System Equipment Housings, Assemblies, And Related Alignment Feature," which is incorporated herein by reference in its entirety.

This application is also related to U.S. Provisional Patent Application Ser. No. 61/316,584 filed Mar. 23, 2010 entitled "Modular Distributed Antenna System Equipment Housings, Assemblies, And Related Alignment Feature," which is incorporated herein by reference in its entirety.

This application is also related to U.S. Provisional Patent Application Ser. No. 61/316,591 filed Mar. 23, 2010 entitled "Modular Distributed Antenna System Equipment Housings, Assemblies, And Related Alignment Feature," which is incorporated herein by reference in its entirety.

This application is also related to U.S. patent application Ser. No. 12/751,895 entitled "Optical Interface Cards, Assemblies, and Related Methods, Suited For Installation and Use In Antenna System Equipment," which is incorporated herein by reference in its entirety.

BACKGROUND

1. Field of the Disclosure

The technology of the disclosure relates generally to enclosures for housing distributed antenna system equipment provided in a distributed antenna system. The distributed antenna system equipment can include optical fiber-based distributed antenna equipment for distributing radio frequency (RF) signals over optical fiber to remote antenna units.

2. Technical Background

Wireless communication is rapidly growing, with ever-increasing demands for high-speed mobile data communication. As an example, so-called "wireless fidelity" or "WiFi" systems and wireless local area networks (WLANs) are being deployed in many different types of areas (e.g., coffee shops, airports, libraries, etc.). Wireless communication systems communicate with wireless devices called "clients," which must reside within the wireless range or "cell coverage area" in order to communicate with an access point device.

One approach to deploying a wireless communication system involves the use of "picocells." Picocells are radio frequency (RF) coverage areas. Picocells can have a radius in the range from a few meters up to twenty meters as an example. Combining a number of access point devices creates an array of picocells that cover an area called a "picocellular coverage area." Because the picocell covers a small area, there are typically only a few users (clients) per picocell. This allows for minimizing the amount of RF bandwidth shared among the wireless system users. In this regard, head-end communication equipment can be provided to receive incoming RF signals from a wired or wireless network. The head-end communication equipment distributes the RF signals on a communication downlink to remote antenna units distributed throughout a building or facility. Client devices within range of the picocells can receive the RF signals and can commu-

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unicate RF signals back to an antenna in the remote antenna unit, which are communicated back on a communication uplink to the head-end communication equipment and onto the network. The head-end communication equipment may be configured to convert RF signals into optical fiber signals to be communicated over optical fiber to the remote antenna units.

It may be desirable to provide a housing or enclosure for communication equipment for a distributed antenna system that is easily assembled. Thus, the housing or enclosure can be easily assembled in the field. Further, it may further be desirable to provide communication equipment for a distributed antenna system that is compatible with expansion of picocells. Thus, it may be desirable to provide communication equipment for a distributed antenna system that can be easily upgraded or enhanced to support an increased number of remote antenna units, as an example. It may be further desired to allow technicians or other users to provide this increased support in the field, thus making it desirable to allow equipment changes and upgrades to easily be made in the communication equipment with ease and proper function.

SUMMARY OF THE DETAILED DESCRIPTION

Embodiments disclosed in the detailed description include communications equipment housings, assemblies, and related alignment features and methods. The equipment may be distributed antenna equipment. In one embodiment, a communications card is provided. The communications card may be a communications card for an optical fiber-based communications system as a non-limiting example. The communications card in this embodiment comprises a printed circuit board (PCB) having a first end and a second end opposite the first end. At least one radio-frequency (RF) communications component and at least one digital communications component are disposed in the PCB. Further, at least one radio-frequency (RF) connector is provided and disposed at the first end of the PCB and coupled to the at least one RF communications component. At least one digital connector is disposed at the first end of the PCB and coupled to the at least one digital communications component. The at least one digital connector is configured to engage at least one complementary digital connector to align the at least one RF connector with at least one complementary RF connector, prior to the at least one RF connector engaging the at least one complementary RF connector.

In another embodiment, a communications assembly is provided. The communications assembly comprises a communications board having a first end and a second end opposite the first end. The communications board includes at least one radio-frequency (RF) connector disposed at the first end of the communications board, and at least one digital connector disposed at the first end of the communications board. The communications assembly further comprises an interface printed circuit board (PCB) card. The at least one digital connector is configured to engage at least one complementary digital connector disposed in the interface PCB card to align the at least one RF connector with at least one complementary RF connector disposed in the interface PCB card, prior to the at least one RF connector engaging the at least one complementary RF connector.

In another embodiment, a method of aligning communications connectors disposed in a communications card is provided. The method includes providing a communications card having a first end and a second end opposite the first end. The method also includes initially engaging at least one digital connector disposed at the first end of the communications

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card with at least one complementary digital connector prior to engagement of at least one radio-frequency (RF) connector disposed at the first end of the communications card to align the at least one RF connector with at least one complementary RF connector. The method also includes further engaging the at least one digital connector with the at least one RF connector aligned to the at least one complementary RF connector to further engage the at least one RF connector with the at least one complementary RF connector.

In another embodiment, a printed circuit board (PCB) assembly is provided. The PCB assembly comprises a first PCB including one or more first openings disposed through the first PCB, and wherein the first PCB connects to an assembly. The PCB assembly also comprises a second PCB including one or more second openings disposed through the second PCB, and wherein the second PCB connects to the assembly. A standoff is also provided in the PCB assembly that connects the first PCB to the second PCB, wherein the second PCB connects to the assembly and wherein the standoff allows the first PCB to float with respect to the second PCB to align the first PCB in the assembly prior to the first PCB connecting to the assembly.

In another embodiment, a distributed antenna system assembly is provided that includes at least one first plate including at least one first locating alignment slot. The enclosure also includes at least one second plate connected to the at least one first plate to form an enclosure, wherein the at least one second plate includes at least one second locating alignment slot. A midplane support is also provided and configured to support a midplane interface card in a datum plane for establishing at least one connection to at least one distributed antenna system component. The midplane support includes at least two integral locating tabs for engaging the at least one first locating alignment slot and the at least one second locating alignment slot to align the midplane support in at least two dimensions with respect to the at least one first plate and the at least one second plate. In this manner, when a distributed antenna system component is alignedly attached to the midplane support, the distributed antenna system component is also properly aligned with the enclosure by alignment of the midplane support to the enclosure for aligned connections.

Embodiments disclosed in the detailed description also include modular distributed antenna system equipment housings, assemblies, and related alignment features. In one embodiment, a modular distributed antenna system assembly is disclosed. The assembly includes at least one first plate including at least one first locating alignment slot. The assembly also includes at least one second plate including at least one locating tab. The at least one locating tab engages with the at least one first locating alignment slot to align the at least one first plate in at least two dimensions to the at least one second plate to form an enclosure configured to support at least one distributed antenna system component.

It is to be understood that both the foregoing general description and the following detailed description present embodiments, and are intended to provide an overview or framework for understanding the nature and character of the disclosure. The accompanying drawings are included to provide a further understanding, and are incorporated into and constitute a part of this specification. The drawings illustrate various embodiments, and together with the description serve to explain the principles and operation of the concepts disclosed.

BRIEF DESCRIPTION OF THE FIGURES

FIG. 1 is a partially schematic cut-away diagram of an exemplary building and building infrastructure in which a distributed antenna system is employed;

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FIG. 2 is an exemplary schematic diagram of an exemplary head-end communications unit ("HEU") deployed in the distributed antenna system in FIG. 1;

FIG. 3 is an exemplary distributed antenna system equipment housing assembly ("assembly") and enclosure configured to support the HEU of FIG. 2;

FIG. 4 is an exemplary optical interface module (OIM) comprised of a pair of optical interface cards (OIC) configured to be installed in the distributed antenna system equipment housing assembly of FIG. 3 as part of the HEU;

FIG. 5 is a front view of the enclosure of FIG. 3 with a midplane interface card of the HEU of FIG. 2 installed therein;

FIG. 6 is a rear side perspective view of the enclosure of FIG. 3 with the midplane interface card of FIG. 5 installed on a midplane support installed therein;

FIG. 7 is a close-up front, right side perspective view of the midplane interface card of FIG. 5 installed on a midplane support installed in the enclosure of FIG. 3;

FIG. 8 illustrates a front side of the midplane interface card of FIG. 5 without connectors attached to the midplane interface card;

FIG. 9 illustrates a rear view of the enclosure of FIG. 3 with a downlink base transceiver interface (BTS) card (BIC) being inserted into the enclosure and an uplink BIC fully inserted into the enclosure and connected to the midplane interface card disposed in the enclosure;

FIGS. 10A and 10B illustrate front and rear perspective views, respectively, of BIC assemblies that can be inserted in the enclosure of FIG. 3 with the BIC disposed in the assemblies connected to the midplane interface card disposed in the enclosure of FIG. 3;

FIG. 11 illustrates a bottom view of the BIC assembly of FIGS. 10A and 10B;

FIG. 12 illustrates a top view of the BIC assembly of FIGS. 10 and 10B installed in the enclosure of FIG. 3;

FIG. 13 is a side perspective view of the assembly of FIG. 3 with downlink BIC connectors for the downlink BIC and uplink BIC connectors for the uplink BIC disposed in downlink and uplink BIC connector plates, respectively, which are attached to the front of the enclosure;

FIG. 14 is a front perspective view of the BIC connector plate illustrated in FIG. 13 with BIC connectors disposed therethrough;

FIG. 15 is a rear perspective view of the BIC connector plate with BIC connectors disposed therethrough illustrated in FIG. 14;

FIG. 16 is a rear side perspective view of the enclosure of FIG. 13 illustrating cables connected to the BIC connectors disposed through the BIC connector plates routed through openings in the midplane support to the downlink BIC and uplink BIC disposed in the enclosure;

FIG. 17 is a top view of the enclosure of FIG. 13 illustrating cables connected to the BIC connectors disposed through the BIC connector plates routed through openings in the midplane support to the downlink BIC and uplink BIC disposed in the enclosure;

FIG. 18 is a front exploded perspective view of plates of the enclosure of FIG. 3 that are assembled together in a modular fashion to form the enclosure;

FIGS. 19A and 19B illustrate top and bottom perspective views of the enclosure of FIG. 3;

FIG. 20 illustrates a close-up view of the engagement of the top plate of the enclosure in FIG. 3 with a side plate and midplane support of the enclosure of FIG. 3;

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FIG. 21 illustrates a close-up view of locating tabs disposed in the top plate of the enclosure of FIG. 3 engaged with alignment slots disposed in the side plate of the enclosure of FIG. 3;

FIG. 22 is a side view of the OIM that can be disposed in the enclosure of FIG. 3;

FIG. 23 is another perspective side view of the OIM that can be disposed in the enclosure of FIG. 3;

FIG. 24 is a rear perspective view of the OIM that can be disposed in the enclosure of FIG. 3;

FIG. 25 is a perspective view of an alignment block that secures the OIC to an OIM plate of the OIM of FIGS. 23 and 24;

FIG. 26A is a rear perspective view the OIM of FIGS. 23 and 24 without shields installed;

FIG. 26B is a rear perspective view the OIM of FIGS. 23 and 24 with shield plates installed;

FIG. 27 is a close-up rear view of the OIM of FIGS. 23 and 24 showing standoffs disposed between two printed circuit boards (PCBs) of the OICs, wherein one of the PCBs is a floating PCB;

FIG. 28 is a cross-sectional side view of the PCBs of the OICs secured to each other via the standoffs of FIG. 27 to provide one of the OIC PCBs as a floating PCB and the other of the OIC PCBs as a fixed PCB;

FIGS. 29A and 29B are perspective views of the floating standoffs in FIG. 27;

FIGS. 29C and 29D are side and top views, respectively, of the standoffs of FIG. 31;

FIG. 30 is a side cross-sectional view of the standoff of FIG. 27;

FIG. 31 is a side cross-sectional view of an alternative standoff that can be employed to secure the OIC PCBs and provide one of the OIC PCBs as a floating PCB;

FIGS. 32A and 32B are side cross-sectional views of an alternative standoff that can be employed to secure the OIC PCBs and shield plates and provide one of the OIC PCBs as a floating PCB;

FIG. 33 is a side view of the assembly of FIG. 3 showing an OIC digital connector being connected to a complementary connector disposed in the midplane interface card to align the OIC RF connector to be connected to the complementary RF connector disposed in the midplane interface card;

FIG. 34 is a top perspective view of an OIC disposed in the OIM of FIGS. 26A and 26B illustrating the extension of the OIC PCB of beyond transmitter optical sub-assemblies (TO-SAs) and receiver optical sub-assemblies (ROSAs) disposed in the OIC PCB;

FIG. 35 is a front perspective view of the assembly and enclosure of FIG. 3 with a cooling fan protector plate installed to protect a cooling fan installed in the enclosure;

FIG. 36 is a side cross-sectional view of the enclosure of FIG. 35 illustrating a cooling fan duct disposed behind the cooling fan in the enclosure to direct air drawn into the enclosure by the cooling fan into a lower plenum of the enclosure;

FIG. 37 is an exemplary schematic diagram of air flow drawn into the enclosure by the cooling fan through the enclosure of FIG. 35;

FIG. 38 is another side cross-sectional view of the enclosure of FIG. 35 illustrating the directing of air through openings in a lower plenum plate through OICs installed in the enclosure and through openings disposed in an upper plenum plate in the enclosure;

FIG. 39 is a rear perspective view of the enclosure of FIG. 35 illustrating an air outlet from the upper plenum of the enclosure;

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FIG. 40 is a rear perspective view of the enclosure of FIG. 35 illustrating the air outlet from the upper plenum of the enclosure with the top plate of the enclosure removed and illustrating openings in the upper plenum plate into the uplink BIC compartment of the enclosure; and

FIG. 41 is a top view of the uplink BIC with openings disposed therein to allow air to flow from the downlink BIC to the uplink BIC disposed above the downlink BIC in the enclosure of FIG. 35.

DETAILED DESCRIPTION

Reference will now be made in detail to the embodiments, examples of which are illustrated in the accompanying drawings, in which some, but not all embodiments are shown. Indeed, the concepts may be embodied in many different forms and should not be construed as limiting herein; rather, these embodiments are provided so that this disclosure will satisfy applicable legal requirements. Whenever possible, like reference numbers will be used to refer to like components or parts.

Embodiments disclosed in the detailed description include equipment housings, assemblies, and related alignment features and methods. The equipment may be distributed antenna equipment.

Before discussing the exemplary distributed antenna system equipment, assemblies and enclosures and their alignment features, which start at FIG. 3, an exemplary distributed antenna system is first described with regard to FIGS. 1 and 2. In this regard, FIG. 1 is a schematic diagram of a partially schematic cut-away diagram of a building 10 that generally represents any type of building in which a distributed antenna system 12 might be deployed. The distributed antenna system 12 incorporates a head-end communications unit or head-end unit (HEU) 14 to provide various types of communication services to coverage areas within an infrastructure 16 of the building 10. The HEU 14 is simply an enclosure that includes at least one communication component for the distributed antenna system 12. For example, as discussed in more detail below, the distributed antenna system 12 in this embodiment is an optical fiber-based wireless communication system that is configured to receive wireless radio frequency (RF) signals and provide the RF signals as Radio-over-Fiber (RoF) signals to be communicated over optical fiber 18 to remote antenna units (RAUs) 20 distributed throughout the building 10. The distributed antenna system 12 in this embodiment can be, for example, an indoor distributed antenna system (IDAS) to provide wireless service inside the building infrastructure 10. These wireless services can include cellular service, wireless services such as radio frequency identification (RFID) tracking, wireless fidelity (WiFi), local area network (LAN), and combinations thereof, as examples.

The terms “fiber optic cables” and/or “optical fibers” include all types of single mode and multi-mode light waveguides, including one or more optical fibers that may be upcoated, colored, buffered, ribbonized and/or have other organizing or protective structure in a cable such as one or more tubes, strength members, jackets or the like. Likewise, other types of suitable optical fibers include bend-insensitive optical fibers, or any other expedient of a medium for transmitting light signals. An example of a bend-insensitive optical fiber is ClearCurve® Multimode fiber commercially available from Corning Incorporated.

With continuing reference to FIG. 1, the infrastructure 16 includes a first (ground) floor 22, a second floor 24, and a third floor 26. The floors 22, 24, 26 are serviced by the HEU 14 through a main distribution frame 28 to provide a coverage

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area 30 in the infrastructure 16. Only the ceilings of the floors 22, 24, 26 are shown in FIG. 1 for simplicity of illustration. In this example embodiment, a main cable 32 has a number of different sections that facilitate the placement of a large number of RAUs 20 in the infrastructure 16. Each RAU 20 in turn services its own coverage area in the coverage area 30. The main cable 32 can include, for example, a riser section 34 that carries all of the uplink and downlink optical fiber cables to and from the HEU 14. The main cable 32 can include one or more multi-cable (MC) connectors adapted to connect select downlink and uplink optical fiber cables, along with an electrical power line, to a number of optical fiber cables 36.

In this example embodiment, an interconnect unit 38 is provided for each floor 22, 24, and 26. The interconnect units 38 include an individual passive fiber interconnection of optical fiber cable ports. The optical fiber cables 36 include matching connectors. In this example embodiment, the riser section 34 includes a total of thirty-six (36) downlink and thirty-six (36) uplink optical fibers, while each of the six (6) optical fiber cables 36 carries six (6) downlink and six (6) uplink optical fibers to service six (6) RAUs 20. The number of optical fiber cables 36 can be varied to accommodate different applications, including the addition of second, third, etc. HEUs 14.

According to one aspect, each interconnect unit 38 can provide a low voltage DC current to the electrical conductors in the optical fiber cables 36 for powering the RAUs 20. For example, the interconnect units 38 can include an AC/DC transformer to transform 110V AC power that is readily available in the infrastructure 16. In one embodiment, the transformers supply a relatively low voltage DC current of 48V or less to the optical fiber cables 36. An uninterrupted power supply could be located at the interconnect units 38 and at the HEU 14 to provide operational durability to the distributed antenna system 12. The optical fibers utilized in the optical fiber cables 36 can be selected based upon the type of service required for the system, and single mode and/or multi-mode fibers may be used.

The main cable 32 enables multiple optical fiber cables 36 to be distributed throughout the infrastructure 16 (e.g., fixed to the ceilings or other support surfaces of each floor 22, 24 and 26) to provide the coverage area 30 for the first, second and third floors 22, 24 and 26. In this example embodiment, the HEU 14 is located within the infrastructure 16 (e.g., in a closet or control room), while in another example embodiment, the HEU 14 may be located outside of the building at a remote location. A base transceiver station (BTS) 40, which may be provided by a second party such as cellular service provider, is connected to the HEU 14, and can be co-located or located remotely from the HEU 14. A BTS is any station or source that provides an input signal to the HEU 14 and can receive a return signal from the HEU 14. In a typical cellular system, for example, a plurality of BTSs are deployed at a plurality of remote locations to provide wireless telephone coverage. Each BTS serves a corresponding cell and when a mobile station enters the cell, the BTS communicates with the mobile station. Each BTS can include at least one radio transceiver for enabling communication with one or more subscriber units operating within the associated cell.

The HEUs 14 are host neutral systems in this embodiment which can provide services for one or more BTSs 40 with the same infrastructure that is not tied to any particular service provider. The HEU 14 is connected to six (6) optical fiber cables 36 in this embodiment.

FIG. 2 is a schematic diagram of the exemplary HEU 14 provided in the distributed antenna system 12 of FIG. 1 to provide further detail. As illustrated therein, the HEU 14

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includes a number of exemplary distributed antenna system components. A distributed antenna system component can be any component that supports communication for the distributed antenna system, such as the distributed antenna system 12 of FIG. 1. For example, a head-end controller (HEC) 42 is included that manages the functions of the HEU 14 components and communicates with external devices via interfaces, such as a RS-232 port 44, a Universal Serial Bus (USB) port 46, and an Ethernet port 48, as examples. The HEU 14 can be connected to a plurality of BTSs, transceivers, etc. at BIC connectors 50, 52. BIC connectors 50 are downlink connectors and BIC connectors 52 are uplink connectors. Each downlink BIC connector 50 is connected to a downlink BTS interface card (BIC) 54 located in the HEU 14, and each uplink BIC connector 52 is connected to an uplink BIC 56 also located in the HEU 14. The downlink BIC 54 is configured to receive incoming or downlink RF signals from the BTS inputs, as illustrated in FIG. 2, to be communicated to the RAUs 20. The uplink BIC 56 is configured to provide outgoing or uplink RF signals from the RAUs 20 to the BTSs as a return communication path.

The downlink BIC 54 is connected to a midplane interface card 58. The uplink BIC 56 is also connected to the midplane interface card 58. The downlink BIC 54 and uplink BIC 56 can be provided in printed circuit boards (PCBs) that include connectors that can plug directly into the midplane interface card 58. The midplane interface card 58 is also in direct electrical communication with a plurality of optical interface cards (OICs) 60, which are in optical and electrical communication with the RAUs 20 via the optical fiber cables 36. The OICs 60 convert electrical RF signals from the downlink BIC 54 to optical signals, which are then communicated over the optical fiber cable 36 to the RAUs 20. The OICs 60 in this embodiment support up to three (3) RAUs 20 each.

The OICs 60 can also be provided in a PCB that includes a connector that can plug directly into the midplane interface card 58 to couple the links in the OICs 60 to the midplane interface card 58. In this manner, the exemplary embodiment of the HEU 14 is scalable to support up to thirty-six (36) RAUs 20 since the HEU 14 can support up to twelve (12) OICs 60. If less than thirty-four (34) RAUs 20 are to be supported by the HEU 14, less than twelve OICs 60 can be included in the HEU 14 and connected into the midplane interface card 58. An OIC 60 is needed for every three (3) RAUs 20 supported by the HEU 14 in this embodiment. OICs 60 can also be added to the HEU 14 and connected to the midplane interface card 58 if additional RAUs 20 are desired to be supported beyond an initial configuration. In this manner, the number of supported RAUs 20 by the HEU 14 is scalable and can be increased or decreased, as needed and in the field, by simply connecting more or less OICs 60 to the midplane interface card 58.

FIG. 3 illustrates an exemplary distributed antenna system housing assembly 70 (referred to as "assembly 70") that may be employed to provide an HEU, such as the HEU 14 in FIG. 2. An HEU is simply at least one communications component provided in an enclosure or housing. As will be described in more detail below, the assembly 70 is modular. The assembly 70 is configured to be easily assembled in a factory or in the field by a technician. Further, the assembly 70 supports a number of features that allow interface cards to be easily inserted and aligned with respect to the midplane interface card 58 to ensure that proper connections are made with other components of the HEU 14 that form part of the distributed antenna system, such as the distributed antenna system 12 in FIG. 1, for example. As illustrated in FIG. 3, the assembly 70 includes an enclosure 72. The enclosure 72 is comprised of a

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bottom plate 74 (see also, FIG. 14B) and side plates 76A, 76B. An internal cavity 80 is formed in the space formed inside the bottom plate 74 and the side plates 76A, 76B when assembled together for locating components of the HEU 14, such as the components illustrated in FIG. 2, for example. A top plate 82 can also be provided and secured to the side plates 76A, 76B, as illustrated in FIG. 6, to protect the internal cavity 80 and protect components of the HEU 14 disposed therein. Note that only two plates can be provided for the enclosure 72, if desired. For example, one plate could be a first plate wherein a second plate is attached to the first plate. The first plate could be any of the bottom plate 74, the side plates 76A, 76B, and top plate 82. Also, the second plate could be any of the bottom plate 74, the side plates 76A, 76B, and top plate 82.

With continuing reference to FIG. 3, the enclosure 72 is configured to support the OICs 60 illustrated in FIG. 2. In this embodiment as illustrated FIG. 4, the OICs 60 are grouped together in pairs to form an optical interface module (OIM) 84. Thus, an OIM 84 is comprised of two (2) OICs 60 that each support up to three (3) RAUs 20 and thus the OIM 84 supports up to six (6) RAUs 20 in this embodiment. As illustrated in FIG. 4, each OIC 60 is provided as a PCB 86 with integrated circuits provided therein to provide electrical signal to optical signal conversions for communication downlinks and vice versa for communication uplinks. An OIM plate 88 is provided to assist in coupling a pair of OICs 60 together to form the OIM 84. As will be discussed in more detail below in this disclosure, the pair of OICs 60 are secured to the OIM plate 88 to form the OIM 84. The OIM plate 88 serves to support the OIC 60 and contribute to the alignment the OICs 60 for proper insertion into and attachment to the enclosure 72, which in turn assists in providing for a proper and aligned connection of the OICs 60 to the midplane interface card 58, as shown in FIG. 3. In this embodiment, the PCBs 86 are attached to shield plates 95A, 95B that are attached to the OIM plate 88 to provide mechanical, RF, and other electromagnetic interference shielding.

The OICs 60 are also secured together via standoff connectors 89 that contain alignment features to allow self-alignment between the OICs 60 when connected to the midplane interface card 58, as illustrated in FIG. 4 and as will be described in more detail in this disclosure. Connector adapters 90 are disposed in the OIM plate 88 and provide for optical connections of OIC PCBs 86 of the OICs 60. The connector adapters 90 are disposed through openings 92 in the OIM plate 88 to provide external access when the OIM 84 is installed in the enclosure 72. RAUs 20 can be connected to the connector adapters 90 to establish connections to the OICs 60 of the HEU 14, and thus provided as part of the distributed antenna system 12, via the optical fiber cables 36 in FIG. 1 being connected to the connector adapters 90. These connector adapters 90 may receive any type of fiber optic connector, including but not limited to FC, LC, SC, ST, MTP, and MPO. The OIM 84 is secured to the enclosure 72 via spring-loaded connector screws 85 disposed in the OIM plate 88 that are configured to be inserted into apertures 87 (see FIG. 5) to secure the OIM plate 88 to the enclosure 72, as illustrated in FIG. 3.

To provide flexibility in providing OIMs 84, the HEC 42, and the downlink BIC 54 and uplink BIC 56 in the HEU 14, the enclosure 72 provides for the midplane interface card 58 to be disposed inside the internal cavity 80 extending between the side plates 76A, 76B in a datum plane 81, as illustrated in FIG. 3. As will be discussed in more detail below, alignment features are provided in the midplane interface card 58 and the enclosure 72 such that proper alignment of the midplane

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interface card 58 with the enclosure 72 is effected when the midplane interface card 58 is inserted in the enclosure 72. Thus, when the OIMs 84, the HEC 42, and the downlink BIC 54 and uplink BIC 56 are properly and fully inserted into the enclosure 72, the alignment between these components and the enclosure 72 effect proper aligned connections between connectors on these components (e.g., connectors 94) and the midplane interface card 58. Proper connection to the midplane interface card 58 is essential to ensure proper connection to the proper components in the HEU 14 to support communications as part of a distributed antenna system supported by the HEU 14. Aligning these connections is important for proper connection, especially given that the enclosure 72 is modular and tolerances of the enclosure components in the enclosure 72 can vary.

To illustrate the alignment features to properly align the midplane interface card 58 with the enclosure 72, FIG. 5 is provided to illustrate a front view of the enclosure 72 with the midplane interface card 58 installed therein. FIG. 5 illustrates a front side 93 of the midplane interface card 58. FIG. 6 illustrates a rear perspective view of the enclosure 72 with the midplane interface card 58 installed. No HEU 14 components are yet installed in the enclosure 72 in FIG. 5. FIG. 6 illustrates channels 91A that are disposed in the bottom plate 74 of the enclosure 72 to receive bottom portions of the HEC 42 and OIMs 84 to align these components in the X and Y directions of the enclosure 72. Channels 91B (FIG. 14B) are also disposed on the top plate 82 and are aligned with the channels 91A disposed in the bottom plate 74 to receive top portions of the HEC 42 and OIMs 84 to align these components in the X and Y directions. It is important that the midplane interface card 58 be properly aligned with regard to the enclosure 72 in each of the X, Y, and Z directions, as illustrated in FIG. 5, because the midplane interface card 58 includes connectors 94A, 94B, 94C that receive complementary connectors (described in more detail below) from components of the HEU 14 installed in the enclosure 72.

The connectors 94A are disposed in the midplane interface card 58 and designed to accept connections from the HEC 42 and other like cards with a compatible complementary connector, as illustrated in FIG. 3. The connectors 94B are disposed in the midplane interface card 58 and designed accept digital connections from the OICs 60. The RF connectors 94C are disposed in the midplane interface card 58 and designed to accept RF connections from the OIC 60 (see element 195, FIGS. 21 and 22). The enclosure 72 is designed such that alignment of the HEU 14 components is effected with respect to the enclosure 72 when installed in the enclosure 72. Thus, if the connectors 94A, 94B, 94C are not properly aligned with respect to the enclosure 72, components of the HEU 14, by their alignment with the enclosure 72, may not be able to establish proper connections with the midplane interface card 58 and thus will not be connected to the distributed antenna system provided by the HEU 14.

In this regard, as illustrated in FIGS. 5 and 6, a midplane support 100 is installed in the datum plane 81 of the enclosure 72 to align the midplane interface card 58 in the X, Y, and Z directions with regard to the enclosure 72. The midplane support 100 may be a plate formed from the same material as the bottom plate 74, the side plates 76A, 76B, and/or the top plate 82. The midplane support 100 provides a surface to mount the midplane interface card 58 in the enclosure 72. A divider plate 101 is also provided and attached to the midplane support 100, as illustrated in FIG. 6, to separate compartments for the downlink and uplink BICs 54, 56 and a power supply 59 (FIG. 6) to provide power for the HEC 42 and other components of the HEU 14. As will also be

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described in more detail below, the modular design of the enclosure 72 is provided such that the midplane support 100 is properly aligned in the datum plane 81 in the X, Y, and Z directions when installed in the enclosure 72. Thus, if alignment features are disposed in the midplane support 100 to allow the midplane interface card 58 to be properly aligned with the midplane support 100, the midplane interface card 58 can be properly aligned with the enclosure 72, and as a result, the connectors of the components of the HEU 14 installed in the enclosure 72 will be properly aligned to the connectors 94A, 94B, 94C disposed in the midplane interface card 58.

As illustrated in FIG. 5, two alignment features 102 are disposed in the midplane support 100 and the midplane interface card 58 to align the midplane interface card 58 in the X, Y, and Z directions with respect to the midplane support 100, and thus the enclosure 72. FIG. 7 illustrates a close-up view of the right-hand side of the midplane interface card 58 installed on the midplane support 100 that also shows one of the alignment features 102. The alignment features 102 in this embodiment are comprised of PCB support guide pins 104 that are configured to be disposed in alignment openings 106, 108 disposed in the midplane interface card 58 and midplane support 100, respectively. FIG. 8 illustrates a front side 109 of the midplane interface card 58 without connectors. The PCB support guide pins 104 are installed and configured to be disposed through the alignment openings 106, 108. Before the PCB support guide pins 104 can be inserted through both alignment openings 106, 108 disposed in the midplane interface card 58 and midplane support 100, the alignment openings 106, 108 are aligned with the PCB support guide pins 104. Thus, by this alignment, the midplane interface card 58 is aligned in the X and Y directions with the midplane support 100. For example, the inner diameter of the openings 106, 108 may be 0.003 inches or less larger than the outer diameter of the PCB support guide pin 104. Also, the tolerances between the center lines in the X direction of the alignment openings 106, 108 may be less than 0.01 inches or 0.005 inches, as examples, to provide an alignment between the alignment openings 106, 108 before the PCB support guide pins 104 can be disposed through both alignment openings 106, 108. Any other tolerances desired can be provided.

Once the PCB support guide pins 104 are inserted into the openings 106, 108, the midplane interface card 58 can be screwed in place to the midplane support 100. In this regard, additional openings 110 are disposed in the midplane interface card 58, as illustrated in FIG. 5. These openings 110 are configured to align with openings 112 disposed in the midplane support 100 when the alignment openings 106, 108 are aligned or substantially aligned. A total of twenty (20) or other number of openings 110, 112 are disposed in the midplane interface card 58 and midplane support 100, as illustrated in FIG. 5. Fasteners 114, such as screws for example, can be disposed through the openings 110, 112 to secure the midplane interface card 58 to the midplane support 100 and to, in turn, align the midplane interface card 58 to the midplane support 100 in the Z direction.

FIG. 8 illustrates the midplane interface card 58 without the fasteners 114 disposed in the openings 110 to further illustrate the openings 110. The fasteners 114 are screwed into self-clinching standoff. For example, the self-clinching standoff may be disposed in the midplane support 100. The height tolerances of the self-clinching standoffs may be between +0.002 and -0.005 inches, as an example. The inner diameter of the openings 110 may be 0.030 inches greater than the outer diameter of the fasteners 114, for example, since openings 110 are not used to provide the alignment provided by PCB support guide pins 104 and openings 106,

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108. Further, as illustrated in FIG. 5, openings 115 are disposed in the midplane support 100 to allow cabling to be extended on each side of the midplane interface card 58. The nominal distance in one embodiment between the midplane support 100 and the midplane interface card 58 when installed is 0.121 inches, although any other distances could be provided.

The midplane interface card 58 is also configured to receive direct connections from the downlink BIC 54 and the uplink BIC 56 when installed in the enclosure 72. As illustrated in the rear view of the enclosure 72 in FIG. 9, the downlink BIC 54 and uplink BIC 56 are designed to be inserted through a rear side 116 of the enclosure 72. Referring back to FIG. 8, connector holes 116A, 116B are disposed on the midplane interface card 58 in FIG. 8 show where connectors are provided that are connected to connectors 118 (see FIGS. 10A and 10B) of the downlink BIC 54 and uplink BIC 56 when the downlink BIC 54 and uplink BIC 56 are received are fully inserted into the enclosure 72. The alignment features 102, by being provided between the midplane interface card 58 and the midplane support 100 as previously discussed, also provide proper alignment of the connector holes 116A, 116B to be properly aligned with the connectors 118 in the downlink BIC 54 and uplink BIC 56 when inserted in the enclosure 72.

FIGS. 10A and 10B illustrate a BIC assembly 120 that supports the downlink BIC 54 or the uplink BIC 56 and is configured to be received in the enclosure 72 to connect the downlink BIC 54 or the uplink BIC 56 to the midplane interface card 58. The BIC assembly 120 is the same whether supporting the downlink BIC 54 or the uplink BIC 56; thus, the BIC supported by the BIC assembly 120 in FIGS. 10A and 10B could be either the downlink BIC 54 or the uplink BIC 56. The BIC assembly 120 includes a BIC support plate 122 that is configured to secure the downlink and uplink BICs 54, 56. Standoffs 124 are provided to support a BIC PCB 126 of the downlink and uplink BICs 54, 56 above the BIC support plate 122. A BIC face plate 128 is coupled generally orthogonal to the BIC support plate 122 to secure the downlink and uplink BICs 54, 56 to the enclosure, as illustrated in FIG. 9. Alignment features 130 are provided between the BIC support plate 122 and the BIC face plate 128 to ensure that the BIC PCB 126, and thus its connector 118, are properly aligned in the X and Y directions, as illustrated in FIG. 9, when the downlink and uplink BICs 54, 56 are inserted in the enclosure 72. Thus, the connector 118 will be properly aligned with the enclosure 72 and thus the connector holes 116A, 116B on the midplane interface card 58 to allow a proper connection between the downlink and uplink BICs 54, 56 and the midplane interface card 58. The alignment features 130 will ensure alignment of the BIC PCB 126 as long as the BIC PCB 126 is properly installed on the BIC support plate 122, which will be described in more detail below. As illustrated on the bottom side 127 of the BIC assembly 120 in FIG. 11, the alignment features 130 in this embodiment are protrusions 132 attached to the BIC support plate 122 that are configured to be disposed through openings 134 disposed through the BIC face plate 128, as illustrated in FIG. 10A. The downlink or uplink BIC connectors 50, 52 (see also, FIG. 2), as the case may be, are disposed through the BIC face plate 128 to allow BTS inputs and outputs to be connected to the downlink and uplink BICs 54, 56, external to the enclosure 72 when the downlink and uplink BICs 54, 56 are fully inserted in the enclosure 72.

To provide alignment of the BIC PCB 126 to the BIC support plate 122, alignment features 140 are also disposed in the BIC PCB 126 and the BIC support plate 122, as illustrated

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in FIGS. 10A, 10B, 11 and 12. As illustrated therein, PCB support guide pins 142 are disposed through alignment openings 144, 146 disposed in the BIC PCB 126 and BIC support plate 122, respectively, when aligned. The alignment openings 144 and 146 are designed to only be aligned to allow the PCB support guide pin 142 to be disposed therein when the alignment openings 144, 146 are in alignment. For example, the tolerances between the alignment openings 144, 146 may be less than 0.01 inches or less than 0.005 inches, as examples, to ensure an alignment between the alignment openings 144, 146 before the PCB support guide pins 142 can be disposed through both alignment openings 144, 146. Any other tolerances desired can be provided.

FIGS. 9-12 described above provide the BIC connectors 50, 52 disposed through the rear side 116 of the enclosure 70. To establish connections with the BIC connectors 50, 52, connections are established to the BIC connectors 50, 52 in the rear side 116 of the enclosure 72. Alternatively, the enclosure 72 could be designed to allow connections to be established to the downlink BIC 54 and the uplink BIC 76 from the front side of the enclosure 72. In this regard, FIG. 13 is a side perspective view of the assembly 70 of FIG. 3 with the downlink BIC connectors 50 for the downlink BIC and the uplink BIC connectors 52 for the uplink BIC 56 disposed through a front side 147 of the enclosure 72. As illustrated therein, a downlink BIC connector plate 149 containing downlink BIC connectors 50 disposed therein is disposed in the front side 147 of the assembly 70. Similarly, an uplink BIC connector plate 151 containing uplink BIC connectors 52 disposed therein is also disposed in the front side 147 of the assembly 70.

FIGS. 14 and 15 illustrate front and rear perspective views of an exemplary BIC connector plate, which can be BIC connector plate 149 or 151. As illustrated therein, the BIC connectors 50 or 52 are disposed through the BIC connector plate 149 or 151 so that the BIC connectors 50 or 52 can be accessed externally through the front side 147 of the assembly 70. Fasteners 153 can be disposed through openings 155 in the BIC connector plates 149 or 151 to fasten the BIC connector plates 149 or 151 to the assembly 70. Channel guides 173 are attached to the BIC connector plates 149 or 151 that are configured to be received in the channels 91A, 91B in the assembly 70 to assist in aligning the BIC connector plates 149 or 151 with the assembly 70 when disposing the BIC connector plates 149 or 151 in the assembly 70. Because the downlink BIC 54 and uplink BIC 56 are disposed in the rear of the assembly 70, as illustrated in FIGS. 9-12, the BIC connectors 50 or 52 are provided in the BIC connector plates 149 or 151 to connect the BIC connectors 50 or 52 to the downlink BIC 54 or uplink BIC 56, as illustrated in FIG. 15 and as will be described below with regard to FIGS. 16 and 17. Further, a BIC ribbon connector 157 is disposed in the BIC connector plates 149 or 151 to connect to the downlink BIC 54 or uplink BIC 56 to carry status signals regarding the downlink BIC 54 or uplink BIC 56 to be displayed on visual indicators 161 disposed on the BIC connector plates 149 or 151.

FIG. 16 is a rear side perspective view of the enclosure 72 illustrating cables 165, 167 connected to the BIC connectors 50, 52 being disposed through an opening 169 in the midplane support 100 and an opening 171 in the divider plate 101. The cables 165, 167 provide connections between the BIC connectors 50, 52 and the BIC ribbon connector 157 so that the BIC connectors 50, 52 can be disposed in the front side 147 of the assembly 70 with the downlink BIC 54 and the uplink BIC 56 disposed in the rear of the assembly 70. FIG. 17 is a top view of the assembly 70 further illustrating the routing of the cables 165, 167 connecting the BIC connectors 50, 52 and

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BIC ribbon connector 157 through the openings 169, 171 to the downlink BIC 54 and uplink BIC 56.

The enclosure 72 is also provided as a modular design to allow the enclosure to be easily assembled and to effect proper alignment between the various plates and components that form the enclosure 72. For example, FIG. 18 illustrates a front exploded perspective view of the enclosure 72. As illustrated therein, the enclosure 72 is formed from the side plates 76A, 76B being connected to and between the bottom plate 74 and the top plate 82. The midplane support 100 is configured to be disposed in the datum plane 81 (see FIG. 5) of the enclosure 72 when assembled. The divider plate 101 is configured to be attached to the midplane support 100 generally orthogonal to the datum plane 81 to divide compartments for the downlink and uplink BICs 54, 56 and a power module disposed in the HEU 14 on the rear side of the midplane support 100.

To further illustrate the modularity and ease in assembly of the enclosure 72, FIGS. 19A and 19B illustrate top and bottom perspective view, respectively, of the enclosure 72 to further illustrate how the side plates 76A, 76B are attached to the top plate 82 and bottom plate 74. In this regard, the top and bottom plates 82, 74 include an alignment feature in the form of locating tabs 150, 152. The locating tabs 150, 152 are integrally formed in the top and bottom plates 74, 82 and are configured to engage with complementary alignment openings or alignment slots 154, 156 integrally disposed in the side plates 76A, 76B. FIGS. 19A and 19B also illustrates a close-up view of the top plate 82 attached to the side plate 76B and the locating tabs 150 engaged with the alignment slots 154. This allows the top and bottom plates 74, 82 to be attached in proper alignment quickly and easily with the side plates 76A, 76B when assembling the enclosure 72. In the enclosure 72, there are four (4) locating tabs 150, 152 on each side of the top and bottom plates 82, 74, and four (4) complementary alignment slots 154, 156 disposed on each side of the side plates 76A, 76B, although any number of locating tabs and slots desired can be employed. Fasteners can then be employed, if desired to secure the locating tabs 150, 152 within the alignment slots 154, 156 to prevent the enclosure 72 from disassembling, as illustrated in FIG. 20. FIG. 20 also illustrates a close-up view of the top plate 82 attached to the side plate 76B in this regard.

As illustrated in FIG. 20, the top plate 82 contains rolled or bent up sides 180 that are configured to abut tightly against and a top inside side 182 of the side plate 76B. The same design is provided between the top plate 82 and the side plate 76A, and the bottom plate 74 and the side plates 76A, 76B. An outer width W_1 of the top and bottom plates 82, 74 is designed such that the fit inside an inner width W_2 of the side plates 76A, 76B, as illustrated in FIG. 19A. Fasteners 184 disposed in openings 186 in the side plates 76A, 76B and openings 188 in the top and bottom plates 82, 74 pull the side plates 76A, 76B and the top and bottom plates 82, 74 close together tightly to provide a tight seal therebetween. Further, as illustrated in FIG. 20, an alignment tab 181 extending from the midplane support 100 is shown and extends into a slot 183 disposed in the top plate 82 to further align the midplane support 100 with the enclosure 72.

FIG. 21 also illustrates alignment features provided in the midplane support 100 that are configured to align the midplane support 100 with the enclosure 72. As illustrated in FIG. 21, the top plate 82 includes integral alignment slots 160 in the datum plane 81 when the top plate 82 is secured to the side plate 76B. The side plate 76B also includes alignment slots 162 integrally disposed along the datum plane 81 when the side plate 76B is secured to the top plate 82. The midplane

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support 100 includes locating tabs 164 that are disposed through the alignment slots 160, 162 when the midplane support 100 is properly aligned with the enclosure 72 and the top plate 82 and side plate 76B (see also, FIG. 7). In this manner, as previously described, when the midplane interface card 58 is properly aligned with the installed midplane support 100, the midplane interface card 58 is properly aligned with the enclosure 72 and thus any HEU 14 components installed in the enclosure 72. Alignment slots 166 similar to alignment slots 160 are also integrally disposed in the bottom plate 74, as illustrated in FIG. 19B. These alignment slots 166 are also configured to receive locating tabs 168 in the midplane support 100, as illustrated in FIG. 19B, to align the midplane support 100.

Further, as illustrated in FIGS. 19A and 19B, the enclosure 72 is also configured to receive and support removable mounting brackets 170A, 170B to secure the enclosure 72 to an equipment rack. As illustrated therein, the mounting brackets 170A, 170B include folded down components that form tabs 172A, 172B. The side plate 76A, 76B include integral alignment slots 174, 176, respectively, that are configured to receive the tabs 172A, 172B. To secure the tabs 172A, 172B to the enclosure 72, fasteners 178A, 178B are disposed through openings 179A, 179B in the tabs 172A, 172B, respectively, and secure to the top plate 82 and bottom plate 74.

Other features are provided to support alignment of components of the HEU 14 and to support proper connection of these components to the midplane interface card 58. For example, one of these components is the OIM 84, as previously discussed. The OIM 84 is illustrated in FIG. 22, wherein fiber routing guides 190 can be disposed on the outside of the PCB 86 of the OIC 60 to assist in routing optical fibers 192 from connector adapters 90 that are configured to connect to optical fibers connected to the RAUs 20 (see FIG. 2). The optical fibers 192 are connected to the electronic components of the OIC 60 to convert the received optical signals from the RAUs 20 into electrical signals to be communicated to the uplink BIC 56 via connector 194 and RF connectors 195 that are connected to the midplane interface card 58 when the OIM 84 is inserted into the enclosure 72, as previously discussed.

As previously discussed, the OIM 84 includes two OICs 60 connected to the OIM plate 88 to be disposed in channels 91A, 91B in the enclosure 72. Also, by providing two OICs 60 per OIM 84, it is important that the connectors 194 are properly aligned and spaced to be compatible with the alignment and spacing of the complementary connectors 94B in the midplane interface card 58 (see FIG. 5). Otherwise, the OICs 60 may not be able to be properly connected to the midplane interface card 58. For example, if the PCBs 86 of the OICs 60 are not both secured in proper alignment to the OIM plate 88, as illustrated in FIG. 23, one or both OICs 60 may not be aligned properly in the Z direction.

In this regard, FIG. 24 illustrates an alignment feature 200 to ensure that the PCBs 86 of the OICs 60 are properly secured and aligned with regard to the OIM plate 88 in the Z direction. As illustrated in FIG. 24 and more particularly in FIG. 25, an alignment block 202 is provided. As illustrated in FIG. 25, the alignment block 202 includes two alignment surfaces 204A, 204B. As illustrated in FIGS. 24 and 25, alignment surface 204A is configured to be disposed against the surface of the PCB 86. Alignment surface 204B is configured to be disposed against a rear surface 206 of the OIM plate 88, as also illustrated in FIG. 24. As illustrated in FIG. 25, guide pin 208 extends from the alignment surface 204A that is configured to be disposed in an opening in the PCB 86

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of the OICs 60. An opening 210 disposed in the alignment surface 204A is configured to align with an opening disposed in the PCB 86 wherein a fastener can be disposed therein and engaged with the opening 210 to secure the PCB 86 to the alignment block 202. To align the alignment block 202 to the PCB 86, the guide pin 208 is aligned with an opening in the PCB 86 and inserted therein when aligned.

The alignment surface 204B also contains an opening 212 that is configured to receive a fastener 214 (FIG. 23) disposed through the OIM plate 88 and engage with the opening 212. Some of the fasteners 214 may be configured to also be disposed through openings in the connector adapters 90, as illustrated in FIG. 23, to secure both the connector adapters 90 to the OIM plate 88 and the OIM plate 88 to the OICs 60. In this manner, the OIM plate 88 is secured to the alignment block 202, and the alignment block 202 is aligned and secured to the PCB 86. Thus, the OIM plate 88 is aligned with the PCB 86 of the OIC 60 in the Z direction.

Further, when tolerances are tight, it may be difficult to ensure proper mating of all connectors 194, 94B between the OICs 60 and the midplane interface card 58. For example, as illustrated in FIG. 23, if the spacing between standoffs 196 securing and spacing apart the PCBs 86 of the OICs 60 is not the same as the spacing between connectors 94B in the midplane interface card 58, alignment of the OICs 60 in the X, Y, or Z directions may not be proper, and thus only one or neither OIC 60 may be able to be connected to the midplane interface card 58 and/or without damaging the midplane interface card 58 and/or its connectors 94B.

In this regard, FIG. 26A illustrates a rear perspective view of the OIM 84 of FIGS. 23 and 24 with standoffs 196 provided between the two PCBs 86 of the OICs 60 that allow one PCB 86 to float with regard to the other PCB 86. FIG. 26B illustrates a rear perspective view of the OIM 84 of FIG. 26A within optional shield plates 95A, 95B installed to the PCBs 86 and to the OIM plate 88 to provide mechanical, RF, and other electromagnetic interference shielding. In this regard, tolerances are eased when the OICs 60 are secured to the OIM plate 88 to allow one connector 194 of an OIC 60 to move or float slightly in the X, Y, or Z directions with regard to the other OIC 60, as illustrated in FIGS. 26A and 26B. FIG. 27 illustrates a close-up view of one standoff 196 between two PCBs 86A, 86B of the OICs 60. As will be described in more detail below, the standoff 196 is allowed to float about the top PCB 86A to allow the positioning or orientation of the top PCB 86A to move slightly in the X, Y, or Z directions with regard to the bottom PCB 86B.

FIG. 28 is a side cross-sectional view of the top and bottom PCBs 86A, 86B of the OIM 84 mounted to each other with the standoff 196, as illustrated in FIGS. 26A and 26B and 28, to further illustrate the floating top PCB 86A. In this regard, the standoff 196 is comprised of a body 199. The body 199 of the standoff 196 is also illustrated in the perspective, side and top view of the standoff in FIGS. 29A-29C, respectively. The body 199 includes a first collar 220 at a first end 222 of the body 199 of an outer diameter OD₁ than is smaller than an outer diameter OD₂ of a second collar 224 located at a second end 226 of the body 199, as illustrated in FIG. 28-30. The first and second collars 220, 224 are configured to be received within openings 228, 230 of the top and bottom PCBs 86A, 86B, as illustrated in FIG. 28. The first end 222 and second end 226 of the body 199 contains shoulders 232, 234 that limit the amount of disposition of the first and second collars 220, 224 through the openings 228, 230 in the top and bottom PCBs 86A, 86B.

As illustrated in FIG. 28, the second collar 224 is designed so that the outer diameter OD₂ includes a tight tolerance with

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the inner diameter of the opening 230. In this manner, the second collar 224 will not float within the opening 230. Further, a height H_2 of the second collar 224 (see FIG. 29C) is less than a width W_3 of the PCB 86A and opening 230 disposed therein, as illustrated in FIG. 28. This allows a head 236 of a fastener 238 to be secured directly onto the outer surface 239 of the bottom PCB 86B when disposed through a threaded shaft 240 of the body 199 to firmly secure the standoff 196 to the bottom PCB 86B. Because of the outer diameter OD_2 and height H_2 provided for the second collar 224 of the standoff 196, the bottom PCB 86B does not float.

However, to allow the top PCB 86A to float, the outer diameter OD_1 and height H_1 of the first collar 220 is different from that of the second collar 224. In this regard, as illustrated in FIGS. 28-29C and 30, the outer diameter OD_1 of the first collar 220 is smaller than the inner diameter of the opening 228. A gap G is formed therebetween to allow the first collar 220 to move slightly with respect to the opening 228 when disposed therein. Further, the height H_1 of the first collar 220 is taller than the width W_1 of the top PCB 86A, as illustrated in FIG. 28. Thus when a fastener 242 is disposed within the threaded shaft 240 and tightened, a head 244 of the fastener 242 will rest against a top surface 246 of the first collar 220. Because the first collar 220 extends in a plane about a top surface 248 of the top PCB 86A, the head 244 of the fastener 242 does not contact the top surface 248 of the PCB 86A. Thus, when the fastener 242 is tightened, a friction fit is not provided between the head 244 and the top surface 248 of the PCB 86A, allowing the top PCB 86A to float with respect to the standoff 196 and the bottom PCB 86B.

FIG. 31 illustrates an alternative standoff 196' that is the same as the standoff 196, but the thread shaft does not extend all the way through the body 199' like the standoff 196 in FIG. 30. Instead, the thread shafts 240A', 240B' are separated. The standoff 196' can still be employed to provide the floating PCB 86 features discussed above. Also note that the standoffs 196, 196' configured to allow a PCB to float can also be provided for the standoffs 196, 196' provided to install any other components of the HEU 14, including but not limited to the downlink BIC 54 and the uplink BIC 56. Further, the design of the bodies 199, 199' may include a hexagonal outer surface over the entire length of the bodies 199, 199'.

FIGS. 32A and 32B are side cross-sectional views of an alternative standoff 250 that can be employed to secure the OIC PCBs 86 and provide one of the OIC PCBs 86 as a floating PCB. The alternative standoff 250 may be employed to secure the OIC PCBs 86 when the shield plates 95A, 95B are installed, as illustrated in FIG. 26B. In this regard, one standoff 252 is configured to be disposed within another standoff 254. The first standoff 252 contains a thread shaft 256 that is configured to receive a fastener to secure a shield plate 95 to the standoff 252 and the OIM 84. The standoff 252 contains a threaded member 255 that is configured to be secured to a threaded shaft 257 disposed in the standoff 254. The standoff 254 contains a collar 258 similar to the collar 220, as described above in FIGS. 28-29B, that surrounds the threaded shaft 257 and is configured to be received inside an opening of an OIC PCB 86 having a greater inner diameter than the outer diameter OD_3 of the collar 258. This allows an OIC PCB 86 disposed on the collar 258 to float with respect to another OIC PCB 86 secured to a thread shaft 260 of the standoff 254. The standoff 254 has a collar 262 having an outer diameter OD_4 that is configured to be received in an opening in an OIC PCB 86 that does not allow float.

Another alignment feature provided by the embodiments disclosed herein is alignment assistance provided by the digital connectors disposed in the midplane interface card 58 that

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accept digital connections from the OICs 60, the downlink BIC 54, and the uplink BIC 56. As previously discussed and illustrated, digital connectors, including connectors 94B, disposed in the midplane interface card 58 receive complementary digital connectors 194 from the OICs 60, the downlink BIC 54, and the uplink BIC 56 when inserted into the enclosure 72. The OICs 60, the downlink BIC 54, and the uplink BIC 56 are designed such that their digital connections are first made to corresponding digital connectors disposed in the midplane interface card 58 when inserted into the enclosure 72 before their RF connections are made to RF connectors disposed on the midplane interface card 58. In this manner, these digital connections assist in aligning the OICs 60, the downlink BIC 54, and the uplink BIC 56 in the X and Y directions with regard to the midplane interface card 58.

In this regard, FIG. 33 illustrates a side view of the assembly 70 showing a digital connector 194 from an OIC 60 being connected to a complementary connector 94B disposed in the midplane interface card 58. As illustrated therein, the digital connector 194 disposed in the OIC 60 is designed such that the digital connector 194 makes a connection with the complementary connector 94B in the midplane interface card 58 before an RF connector 195 disposed in the OIC 60 makes a connection with the complementary RF connector 94C disposed in the midplane interface card 58. In this regard, when the digital connector 194 begins to connect with the complementary connector 94B, the digital connector 194 aligns with the complementary connector 94B. The end of the RF connector 195 in the OIC 60 is still a distance D away from the complementary RF connector 94C. In one non-limiting embodiment, the distance D may be 0.084 inches. Because the digital connectors 194 on the OICs 60 are in a fixed relationship to the RF connectors 195 provided therein in this embodiment, alignment of the digital connectors 194 also provides alignment of the RF connectors 195 of the OICs 60 to the complementary RF connectors 94C disposed in the midplane interface card 58 as well. Thus, as the digital connector 194 is fully inserted in the complementary connector 94B, the RF connector 195 will be aligned with the complementary RF connector 94C when disposed therein. Alignment of the RF connector 195 may be important to ensure efficient transfer of RF signals. This feature may also be beneficial if the RF connections require greater precision in alignment than the digital connections. The same alignment feature can be provided for the downlink BIC 54 and uplink BIC 56.

As previously discussed and illustrated in FIG. 4, the OIM plate 88 provides support for the connectors 90 and for attaching the OICs 60 to the OIM plate 88 to provide alignment of the OICs 60 when inserted into the enclosure 72. An OIM plate 88 is provided to assist in coupling a pair of OICs 60 together to form the OIM 84. The OIM plate 88 serves to support the OICs 60 and contributes to the alignment the OICs 60 for proper insertion into and attachment to the enclosure 72, which in turn assists in providing a proper and aligned connection of the OICs 60 to the midplane interface card 58. In this regard, as illustrated in FIG. 34, one feature that can be provided in the OIM 84 to allow the OIM plate 88 to be provided in embodiments disclosed herein is to provide an OIC PCB 86 that extends beyond receiver optical sub-assemblies (ROSAs) and transmitter optical sub-assemblies (TOSAs) provided in the OIC 60.

As illustrated in FIG. 34, a top perspective view of the OIM 84 is provided illustrating the extension of OIC PCBs 86 beyond transmitter optical sub-assemblies (TOSAs) 262 and receiver optical sub-assemblies (ROSAs) 260. The TOSAs 262 and ROSAs 260 are connected via optical fibers 263, 265

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to the connectors **90** that extend through the OIM plate **88** to allow connections to be made thereto. By extending the OIC PCBs beyond the TOSAs **262** and ROSAs **260**, the OIM plate **88** can be secured to the OIC PCBs **86** without interfering with the TOSAs **262** and ROSAs **260**. In this embodiment, the TOSAs **262** and ROSAs **260** are mounted or positioned on an end of a PCB to transmit and/or receive optical signals interfaced with electrical signal components disposed in the OIC PCB **86**. Mounting or positioning of TOSAs **262** and ROSAs **260** on the end of a PCB may limit the length of exposed, unshielded wire extensions between the TOSAs **262** and ROSAs **260** and printed traces on the PCB. This provides for signal integrity of the signals after conversion to electrical signals.

Thus, a sufficient space is provided to allow for the TOSAs **262** and ROSAs **260** to extend beyond an end of a PCB. In this regard, openings **264**, **266** are disposed in the OIC PCB **86** in this embodiment. The openings **264**, **266** allow the TOSAs **262** and ROSAs **260** to be disposed in the OIC PCB **86** without the TOSAs **262** and ROSAs **260** extending beyond an end **268** of the OIC PCB **86** where the OIM plate **84** is disposed. Thus, the openings **264**, **266** allow the TOSAs **262** and ROSAs **260** to be disposed at an end **270** of the PCB where the openings **264**, **266** start, but not at the end **268** of the OIC PCB **86** where the OIM plate **88** is located. In this manner, space is provided for the TOSAs **262** and ROSAs **260** such that they do not interfere with or prevent the OIM plate **88** from being disposed at the end **268** of the OIC PCB **86**.

It may also be desired to provide a cooling system for the assembly **70**. The components installed in the assembly **70**, including the downlink BIC **54**, the uplink BIC **56**, the HEC **42**, and the OICs **60** generate heat. Performance of these components may be affected if the temperature due to the generated heat from the components is not kept below a threshold temperature. In this regard, FIGS. **35** and **36** illustrate the assembly **70** and enclosure **72** of FIG. **3** with an optional cooling fan **280** installed therein to provide cooling of components installed in the enclosure **72**. View of the cooling fan **280** is obscured by a cooling fan protector plate **282** in front perspective view of the assembly **70** in FIG. **35**; however, FIG. **36** illustrates a side cross-sectional view of the assembly **70** and enclosure **72** showing the cooling fan **280** installed in the enclosure **72** behind the cooling fan protector plate **282** attached to the enclosure **72**. In this embodiment, cooling is provided by the cooling fan **280** taking air into the enclosure **72** through openings **284** disposed in the cooling fan protector plate **282** and drawing the air across the components in the enclosure **72**, as will be described in more detail below. The air may be pushed through the rear of the enclosure **72** through an air outlet, as illustrated in FIG. **36**. For example, the cooling fan **280** may be rated to direct air at a flow rate of sixty (60) cubic feet per minute (CFM) or any other rating desired.

With continuing reference to FIG. **36**, a lower plenum **286** and an upper plenum **288** is provided in the enclosure **72**. The lower plenum **286** is provided to direct air pulled in the enclosure **72** by the cooling fan **280** initially to the bottom of the enclosure **72** to allow the air to then be directed upward through OICs **60** installed in the enclosure **72** and to the upper plenum **288** to be directed to the rear and outside of the enclosure **72**. Passing air across the OICs **60** cools the OICs **60**. This air flow design is further illustrated in the air flow diagram of FIG. **37**. In this regard, with reference to FIG. **36**, a fan duct **290** is provided behind the cooling fan **280** to direct air drawn into the enclosure **72** by the cooling fan **280**. A plate **292** is installed in the fan duct **290** to direct air flow down from the fan duct **290** into the lower plenum **286**. The air from the

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lower plenum **286** passes through openings disposed in a lower plenum plate **294** and then passes through the openings disposed between OICs **60** wherein the air then passes through openings **296** disposed in an upper plenum plate **298**, as illustrated in FIG. **38**. In this manner, air is directed across the OICs **60** to provide cooling of the OICs **60**. Air then entering into the upper plenum **288** is free to exit from the enclosure **72**, as illustrated in FIG. **36**. The upper plenum **288** is open to the outside of the enclosure **72** through the rear of the enclosure **72**, as illustrated in FIGS. **36** and **37** and in FIG. **39**.

Further, as illustrated in FIGS. **40** and **41**, openings **300** and **302** can also be disposed in the upper plenum plate **298** above the uplink BIC **56** and in the downlink BIC **54** to provide further movement of air for cooling purposes. These openings **300**, **302** allow some of the air flowing into the enclosure **72** from the cooling fan **280** to be drawn from the lower plenum **286** into the downlink BIC **54** and then into the uplink BIC **56** via openings **302**. Air can then be directed from the uplink BIC **56** through openings **300** and into the upper plenum **288** outside of the enclosure **72**.

Further, as illustrated in FIGS. **36**, **39**, and **41** an optional second cooling fan **301** is provided below the upper plenum plate **298**. In this manner, some of the air from the enclosure **72** is drawn through the power supply **59** by the second cooling fan **301** to provide cooling of the power supply **59**. For example, the second cooling fan **301** may be rated to direct air at a flow rate of thirteen (13) cubic feet per minute (CFM) or any other rating desired.

Many modifications and other embodiments set forth herein will come to mind to one skilled in the art to which the embodiments pertain having the benefit of the teachings presented in the foregoing descriptions and the associated drawings. Therefore, it is to be understood that the description and claims are not to be limited to the specific embodiments disclosed and that modifications and other embodiments are intended to be included within the scope of the appended claims. For example, the embodiments disclosed herein can be employed for any type of distributed antenna system, whether such includes optical fiber or not.

It is intended that the embodiments cover the modifications and variations of the embodiments provided they come within the scope of the appended claims and their equivalents. Although specific terms are employed herein, they are used in a generic and descriptive sense only and not for purposes of limitation.

What is claimed is:

1. A communications card, comprising:

a printed circuit board (PCB) having a first end and a second end opposite the first end;

at least one radio-frequency (RF) communications component and at least one digital communications component disposed in the PCB;

at least one radio-frequency (RF) connector disposed at the first end of the PCB and coupled to the at least one RF communications component; and

at least one digital connector disposed at the first end of the PCB and coupled to the at least one digital communications component;

wherein the at least one digital connector is configured to engage at least one complementary digital connector to align the at least one RF connector with at least one complementary RF connector, prior to the at least one RF connector engaging the at least one complementary RF connector.

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2. The communications card of claim 1, wherein the at least one RF connector extends a first distance beyond the first end of the PCB.

3. The communications card of claim 2, wherein the at least one digital connector extends a second distance greater than the first distance beyond the first end of the PCB.

4. The communications card of claim 3, wherein the difference between the first distance and the second distance is less than 0.1 inches.

5. The communications card of claim 3, wherein:
the at least one complementary RF connector extends a third distance beyond a first end of a second PCB;
the at least one complementary digital connector extends a fourth distance at least as great as the third distance beyond the first end of the second PCB; and
the difference between the first distance and the second distance is greater than the difference between the third distance and the fourth distance such that at least one digital connector is configured to engage at least one complementary digital connector prior to the at least one RF connector engaging the at least one complementary RF connector.

6. The communications card of claim 5, wherein the third distance and fourth distance are equal.

7. The communications card of claim 1, wherein the at least one complementary digital connector is disposed in a second PCB.

8. The communications card of claim 1, wherein the at least one complementary RF connector is disposed in a second PCB.

9. The communications card of claim 8, wherein the at least one complementary digital connector is disposed in the second PCB.

10. The communications card of claim 1, wherein the at least one digital connector is blind-mated with the at least one complementary digital connector.

11. The communications card of claim 1, wherein the at least one RF connector is blind-mated with the at least one complementary RF connector.

12. The communications card of claim 1, wherein the communications card is comprised of at least one of a downlink base transceiver station (BTS) interface card (BIC), an uplink BIC, and an optical interface card (OIC).

13. The communications card of claim 1, wherein the at least one RF communications component is configured to communicate Radio-over-Fiber (RoF) signals.

14. The communications card of claim 1, wherein:
the at least one RF connector extends a first distance beyond the first end of the PCB;
the at least one digital connector extends a second distance beyond the first end of the PCB;
the at least one complementary RF connector extends a third distance beyond a first end of a second PCB;
the at least one complementary digital connector extends a fourth distance at least as great as the third distance beyond the first end of the second PCB; and
the sum of the first distance and the third distance is greater than the sum of the second distance and the fourth distance.

15. A communications assembly, comprising:
a communications board having a first end and a second end opposite the first end, and further comprising:
at least one radio-frequency (RF) connector disposed at the first end of the communications board; and
at least one digital connector disposed at the first end of the communications board; and
an interface printed circuit board (PCB) card;

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wherein the at least one digital connector is configured to engage at least one complementary digital connector disposed in the interface PCB card to align the at least one RF connector with at least one complementary RF connector disposed in the interface PCB card, prior to the at least one RF connector engaging the at least one complementary RF connector.

16. The communications assembly of claim 15, wherein the at least one RF connector extends a first distance beyond the first end of the communications board.

17. The communications assembly of claim 16, wherein the at least one digital connector extends a second distance greater than the first distance beyond the first end of the communications board.

18. The communications assembly of claim 17, wherein the difference between the first distance and the second distance is less than 0.1 inches.

19. The communications assembly of claim 15, wherein the interface PCB card is comprised of a midplane interface card.

20. The communications assembly of claim 19, wherein the midplane interface card is mounted to a midplane support mounted in a housing configured to support the midplane interface card in a datum plane of the housing.

21. The communications assembly of claim 20, further comprising at least one alignment feature disposed in the midplane support configured to engage the midplane interface card to align the midplane interface card with the midplane support in at least two dimensions of the housing.

22. The communications assembly of claim 21, wherein the at least one alignment feature is comprised of at least two alignment openings disposed in the midplane support each configured to receive an alignment pin.

23. The communications assembly of claim 15 provided in an antenna equipment housing.

24. A method of aligning communication connectors disposed in a communications card, comprising:

providing a communications card having a first end and a second end opposite the first end;

initially engaging at least one digital connector disposed at the first end of the communications card with at least one complementary digital connector prior to engagement of at least one radio-frequency (RF) connector disposed at the first end of the communications card to align the at least one RF connector with at least one complementary RF connector; and

further engaging the at least one digital connector with the at least one RF connector aligned to the at least one complementary RF connector to further engage the at least one RF connector with the at least one complementary RF connector.

25. The method of claim 24, wherein the at least one RF connector extends a first distance beyond the first end of the communications card.

26. The method of claim 25, wherein the at least one digital connector extends a second distance greater than the first distance beyond from the first end of the communications card.

27. The method of claim 24, wherein the at least one complementary digital connector and the at least one complementary RF connector are disposed in a midplane interface card.

28. The method of claim 27, further comprising mounting the midplane interface card to a midplane support mounted in a housing configured to support the midplane interface card in a datum plane of the housing.

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29. The method of claim **28**, further comprising aligning the midplane interface card with the midplane support to align the communications card with the midplane support and the housing when the at least one digital connector is engaged with the at least one complementary digital connector disposed in the midplane interface card. 5

30. The method of claim **24**, further comprising sliding the communications card into a housing.

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